NATURE

Vol. 147 SATURDAY, JUNE 28, 1941 No. 3739

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LE COQ D'OR

KING DODON was mighty anxious. His kingdom was threatened, yet though in his youth and prime he was a redoubtable monarch, he had long since ceased to care for warlike pursuits. Following the example of their monarch, the people too were contemptuous of the profession of arms, and their young men gave themselves up to pleasure.

The rulers of neighbouring domains were not slow in taking advantage of this state of affairs, so now here was King Dodon threatened with the dangers of invasion. In council, Prince Guidon advised his father. "The chief of our troubles," he said, "is that our enemy is so near to us that he is already about to fall upon our army and annihilate it. Let us, then, bring back our warriors from the borders and place them around our beloved capital to protect it and ourselves from harm."

All the company were delighted, except Prince Afron and the venerable head of the army, Polkan. They angrily opposed such a foolish plan. So King Dodon asked the advice of his son Afron who said : "Recall our soldiers just a month before the enemy attacks, and then we will go forth and crush him."

With all this conflicting advice, no wonder King Dodon was puzzled, and it is not surprising that disorder broke out in the company of the Council.

Then in the midst of this confusion there appeared at the top of the stairway a very old and venerable-looking Astrologer. He carried in one hand an astrolabe and in the other a bag. "Hail, King Dodon ! Although thou knowest not me, yet art thou well known to me. . . . I have come to offer unto thee a magic remedy, so that thou mayest once more sleep in peace. . . . Accept my Golden Cockerel, O Sire, and place it upon the highest spire upon thy palace ; and it shall be a true watchman unto thee. When all is peaceful and quiet, it will make no sound whatever . . . ; but if enemies are about, or if thy peace is threatened in any way, then will my magic Golden Cockerel raise his comb, flap his wings, and turning in the direction from whence the danger appears, will crow aloud 'Cock-a-doodle-do ! Beware !' "

That is how the story of Rimsky-Korsakov's pantomime-opera "Le Coq d'Or" opens. It does not tell us how old that Golden Cockerel was, nor for how many years the Astrologer had possessed it ; but six years ago another 'Golden Cockerel' began to develop, and now, having proved its ability to call "Cock-a-doodle-do ! Beware !" at the appropriate moment, it, together with its 'Astrologer', was introduced to the world by a Minister of State on June 18, 1941.

But there is nothing very new in this announcement and appeal, both at home and overseas, for radio engineers, physicists, etc., to play their part in helping the Cockerel to crow. That is, it is not very new to men of science. Radiolocation, in its origin, was the conception of one man, Mr. R. A. Watson Watt, C.B., F.R.S., scientific adviser on telecommunications to the Chief of the Air Staff, who, with his collaborators and assistants, aided it in its development from chick to adult. No ; neither the Cockerel nor its Astrologer are very new to science, for Watson Watt's researches in radio engineering, especially while at the National Physical Laboratory and at the Bawdsey Research Station, have earned for him a world-wide reputation among men of science, and he is the author of many contributions which have appeared in our columns

The Astrologer said: "Although thou knowest not me, yet art thou well known to me." How true has that been in modern times. How pitifully few of the people, and especially of their leaders, have even bothered to examine what Science has to offer them; and how few are there who know, or express appreciation of, the work of Science behind all the advances—technical, biological, medical, etc.—of this age. It is necessary for national emergencies and modern 'Astrologers' to bring it all home to them. Lord Beaverbrook, on the occasion of the announcement of Watson Watt's great achievement, has now impressed it upon the people that "Technical developments make progress in war which sometimes outstrips all that has gone before. . . . It is the scientist who will heal our wounds. It is the scientist who will protect us against the loss of our life-blood. It is the scientist who will save our home and guard our hearthstones."

Thus on the basis of the work of Watson Watt, Sir Frank Smith and others, did the Minister of State make his call to service: "Man the front line of Science." No doubt men and women from all parts of the world will respond to the call, and thus will Science have made in an almost glamorous way another of her many contributions towards victory in war, for truly this is not only a war of machines—for that is only a part of the story; it is a war of Science, the science of defence, the science of living against great odds, and, alas, the science of destruction.

But what is to be the result of all this? What did the Astrologer demand in the end? He declared that the ordinary gifts of riches and high rank were as nothing to him, since he regarded love only as precious, and at the end of the story he demands the hand of the Queen of Shemakhan. So this is where modern Science and the ancient Astrologer must part company.

Through such men as Watson Watt, the people are learning the first-rate value of Science in modern warfare; so now let Science build up evidence for her claim for all-out recognition and for her just status in times of peace.

How often has this been emphasized in NATURE. But society has still to realize it fully. Even in medicine most people recognize only the medicine of disease. Either they do not recognize or they ignore the medicine of health. They recognize the work of a medical man only when, through illness, they need him. Little do they know of preventive medicine. So is it with Science. Science can be constructive as well as destructive. Which it is to be depends upon society. She offers us a good, strong, useful rope; is it her fault if we choose to hang ourselves with it? Science has played and will have to play, a very important part in the advancement of civilization and the improvement of social life. Little have men of affairs realized or recognized this in the past.

In his appeal, Lord Beaverbrook referred to "the hour when men of science can turn again to the thoughts and the labours of peace". The exigencies of war have constrained many men of affairs to recognize and to appreciate what Science has to offer. The War Minister, too, announced to the House of Commons on June 18 that there might be occasion for the appointment of a special scientific attaché to foreign Governments in view of what Lord Beaverbrook had said in his broadcast appeal. But Science offers more, much more, than weapons of destruction and materials for defence. She offers a horn of plenty, full of good, constructive ideas and machines. When the hour of peace comes, is she to be discarded as something only useful in confounding our enemies? Are Mr. Eden's attachés to be recalled? If so, then our men of affairs will prove to have been opportunists who have learned nothing.

Our Army, Air Force and Navy are in the front line of action. But there are many other fronts—our kitchens, gardens, farms and factories—and not least of all, Science. We have learned of the folly of neglecting our fighting forces in those times of peace when certain sections of the world were treating a period of peace as one of preparation for war. Until the world is ready for a real and lasting peace, we must bear that lesson in mind, once victory is achieved. This applies also to Science. Let her be recognized and encouraged in the everyday lives of the many; let her too be admitted to the council of the chosen few. Never let her be neglected or merely taken for granted again.

Men of science are becoming very conscious of their duty to society. Will society, in the peace to follow, recognize its obligations to Science and avail itself of all the good things that this war is proving Science has to offer? Men of science will be able to offer new and possibly strange tools to society; will society take them and tackle the job of building and maintaining the peace—a job infinitely more difficult than that of winning the war?

"The scientist will heal our wounds."

SOVIET RUSSIA

ON Sunday, June 22, the Nazi war machine was set in motion against Soviet Russia, without even the prelude of an ultimatum.

One by one the nations of Europe have been made subject to direct or indirect Nazi domination, and, with the failure of early attempts to break the resistance of the British Empire and the Free men of the occupied countries now fighting with us, and in apprehension of the effect of the growing weight of support from the United States, the Nazis have turned to the east in an attempt to seize the natural resources of Soviet Russia and to immobilize her armies. Beyond the immediate aims there is little doubt that the intention is to foment strife beyond Europe, in Iran, India and China, and elsewhere in Asia. It is all part of the gigantic scheme to dominate the world by terror and force, to subdue the peoples of all countries and to make them the slaves, body and soul, of Germany.

Mr. Winston Churchill drew a moving picture of the situation as he described it in a broadcast to the world on the evening following the invasion. "It is not too much to say, here this summer evening, that the lives and happiness of a thousand million additional human beings are now menaced with brutal Nazi violence. . . . The Nazi regime is indistinguishable from the worst features of Communism. It is devoid of all theme and principle except appetite and racial domination. It excels all forms of human wickedness in the efficiency of its cruelty and ferocious aggression." A vital decision had to be taken at once by His Majesty's Government, and there will be agreement everywhere with Mr. Churchill's announcement: "We have offered to the Government of Soviet Russia any technical or economic assistance which is in our power and which is likely to be of service to them." It matters not what political label be given for the time being to any nation or group of peoples; we cannot withhold our support from anyone who attempts to withstand the Nazi menace.

Soviet Russia has passed through many vicissitudes since it began to emerge from the Revolution of 1917. Internal difficulties have been numerous. There have been hardship and cruelty. But slowly, and with many hesitating moves, a system of government was built up which bound together the vast Russian territories in Europe and Asia into an organic whole. Some of us may not have sympathized with the ideological background which was developed; others have hailed the evolution of Soviet Russia as a symbol of the form of organized society towards which the nations should move. As Mr. Churchill said, all this must now be put aside. We are faced with an elemental fact. The Russian people now attacked are men and women. They have grown up with a measure of self-government. They have developed the industries of their country; education has been promoted; science and scientific research have received support. Institutes devoted to research have begun to function, as many communications published in NATURE from time to time until a few months ago have shown. Freedom of research as the English-speaking nations know it has not yet been achieved; nevertheless valuable work has been done. We need only recall in this connexion the names of the physicists Kapitza and Joffe, and of the geneticist Vavilov, all of whom have international reputations. These people are being attacked by the sworn enemy of democracy and all that it stands for: "Any man or State who fights Nazism will have our aid."

The attack on Soviet Russia represents, as Mr. Churchill put it, the fourth climacteric in this War; it was marked by "the same kind of outrage against every form of signed compact and international faith which we had witnessed in Norway, Denmark, Holland and Belgium". Freedom of thought leads to freedom of speech, one of the cardinal principles of democracy. This in turn requires the recognition by the individual of the rights and liberties of others; individual liberty must submit to restraints imposed by the needs of society. Such restraints may or may not be codified and become laws, but their observance is a condition upon which the continuance of human society depends. Similarly, in the field of international relationships, the rights of the several nations to their own modes of government must be respected, and the terms of solemnly pledged treaties must be honoured. It will be the task of men of all races, creeds and parties, so to work together after the War that law-breaking among the nations becomes impossible. Lawlessness in international affairs is inimical to the progress of civilization.

HOT SPRINGS AND GEYSERS OF ICELAND

On Thermal Activity in Iceland and Geyser Action

By Thorkell Thorkelsson. Pp. 139. (Reykjavík: Ísafoldarprentsmidja H.F., 1940.)

NOWHERE is thermal spring activity so intense and widespread as in Iceland; many thousands of hot springs are known and in addition many more exist beneath the glaciers and on the shallow sea floor. The lives of the springs vary from a day to hundreds of years. The large spring Reykjalaug is known to have existed in A.D. 1000 for it is reported in the "Kristni saga" that when at that time Christianity was adopted by Parliament the remaining heathen northerners rode to Reykjalaug to be baptized as they refused to suffer this in cold water. In recent years extensive works have been carried out to utilize the springs in heating houses, schools, hospitals and greenhouses and in the provision of public baths. There is a virtually inexhaustible store of energy in the hot ground waters and the future should see further extension of its service to man.

Many famous names are associated with the early study of thermal activity in Iceland; the work of Bunsen is perhaps the best known. No one has paid more attention to the subject than Thorkell Thorkelsson, and this memoir, which includes reflections based upon a life's study, is of prime importance; it is only unfortunate that the absence of sub-headings and somewhat rambling treatment of this long essay will deter some from reading it.

The springs occupy the site of historic volcanic activity and its neighbourhood, and there can be no doubt that the heat is of magmatic origin. With the pouring out of lava at the surface it is reasonable to suppose that a volume of magma remains to cool in the outer part of the earth's crust, and the ground waters are heated by contact with hot rock and by absorption of super-heated steam and other gases given off from the crystallizing magma. It is impossible to determine how much (if any) of the spring water is magmatic, but there is abundant evidence that the water is largely of surface origin—a geyser near the coast at Reykjanes delivers almost pure sea water. Outside the volcanic regions of recent date the gases other than water vapour emanating from the springs consist almost entirely (usually 98 per cent by volume) of nitrogen and argon, in similar proportions to those of the atmosphere, and it may be assumed that in these cases dissolved air has lost its oxygen by combination with the rocks. Within the volcanic region the prominent gases are hydrogen, carbon dioxide and sulphuretted hydrogen, and these are probably of magmatic origin.

Normally the heat is conveyed to the surface and dissipated continuously: only a very small proportion of the springs are geysers. In all likelihood the supply of heat at source is constant and the fundamental cause of geyser action is to be found in the circumstance that the heat acquired in depth cannot be carried away at the rate at which it is added, but accumulates until such instability results that the hot water is violently ejected. The time required for the heating up of the cooler water, then coming in to fill the channels and chambers of the geyser system, readily accounts for the intermittency of the eruptions: the main difficulty is to establish what causes the start of an eruption. Early theories are based on the conception of super-heating: the temperature is supposed to rise at some point until steam is formed with progressive fall of hydrostatic pressure and with consequent expulsion of the water. Observations, however, have not revealed the attainment of super-heat in depth, neither has a continuing increase of temperature been found in the quiescent intervals; if super-heat is attained it must be in greater and inaccessible depths.

Thorkelsson advances reasons for doubting any common development of super-heat; he sees in the spring gases the cause of most geyser eruptions, and cites examples of eruptions where the temperature was below 100° C. "even deep down in the subterranean channels". Gas bubbles are visible in most Icelandic springs and at high temperatures are largely composed of water vapour. "However, the spring gases in spite of their fractional smallness constitute a necessary condition for the existence of the bubbles. If the spring gases were removed the bubbles would collapse immediately."

The essence of Thorkelsson's theory is that swarms of gas bubbles form as the water rises, and the hydrostatic pressure of the gas and water mixture being less than that of water alone (the air-lift pump principle), a reduction of pressure results which may produce an uprush of water sufficient to start the eruption. With this the water will, in many cases, come to boil at the lower pressures experienced in its rise and steam will then play its part; but the fundamental cause of the uprush is considered to lie in the separation of the gas bubbles. It is significant that geysers have been converted into normal springs by putting stones in the channels to retard the flow, also that springs have been converted into geysers by the removal of channel obstructions.

No two geyser systems are the same ; they differ in the number, size, form and attitude of the subterranean spaces. As the upper pipe open to investigation is only a small part of the system and, moreover, is not as a rule the site of the development of the expulsive force, it is not surprising that no general theory can be formulated to cover all cases ; the statement by Day and Allen in their work on "The Hot Springs of the Yellowstone National Park" (1935) that in their experience the permanent gases are extremely scarce in geysers generally must not be forgotten. L. HAWKES.

BIOLOGICAL FIXATION OF NITROGEN

The Biochemistry of Symbiotic Nitrogen Fixation

By Prof. Perry W. Wilson. Pp. xiv+302+34 plates. (Madison, Wis. : University of Wisconsin Press, 1940.) 3.50 dollars.

THE study of the nitrogen fixation which proceeds within nodule-bearing leguminous plants provides a common meeting-ground for several branches of natural science. Bacteriologists, botanists, chemists, students of agriculture, all have found opportunities, not always lucrative, for investigation. The attention lavished on the subject by such varied workers, while it ought to result in a more all-round progress, inevitably complicates the task of anyone attempting to keep in direct touch with the multitude of original publications, dispersed as these are through scientific journals of every description. There should, therefore, be a ready welcome for a monograph such as that prepared by Prof. P. W. Wilson with the help of his colleagues in the Department of Agricultural Bacteriology of the University of Wisconsin, especially since it bears the hallmark of authority of a distinguished centre for the study of biological fixation of nitrogen.

The monograph is described as a sequel to the well-known earlier one from the same department by Fred, Baldwin and McCoy, and refers especially to those aspects of symbiotic nitrogen fixation (chiefly biochemical) that have undergone considerable development in the last decade. Topics dealt with include the biochemistry of the bacteria in pure culture, the interaction of host plant and bacteria, the chemical mechanism of the fixation process, the effect of the carbohydrate-nitrogen balance in the host on fixation, excretion of nitrogenous substances from nodules into rooting medium, physico-chemical studies of possible enzyme systems, and a discussion of practical applications. A certain number of hitherto unpublished observations, views, and conclusions are included, and several hundred references are furnished, mostly to publications of the last ten years. The work is illustrated by numerous photographs and diagrams, most of which are of a high standard and amply fulfil their purpose. It is natural that a considerable proportion of the monograph should be devoted to the statement and consideration of results obtained in the Madison department, in view of the intensive investigations carried out there. Though he writes essentially for the specialist, Prof. Wilson treats his subject in as broad a fashion as possible. Thus in the introductory chapters passages are quoted from agricultural treatises dating from the opening of the Christian era. Anyone feeling this historical approach to be unnecessary would do well to note, as Prof. Wilson does, the complaint made by some modern investigators in this field that earlier workers thought of everything and anticipated many more recent "discoveries".

Prof. Wilson makes a notable attempt to reduce to some sort of order the seemingly chaotic results of studies on certain aspects of the subject, especially those relating to the excretion of nitrogenous substances from the nodules into the rooting medium. He has reached the conclusion that considerable differences may exist in the biochemistry of the same variety of leguminous plant and its nodules when grown under different climatic conditions. This extends to variation in the identity of the intermediates in the fixation process. The occurrence of excretion is considered to be dependent on a particular metabolic event—the accumulation of aspartic acid in the nodules. In this connexion the reviewer may perhaps be allowed to suggest that more attention might be paid by investigators at other stations to those original experiments of Prof. A. I. Virtanen in which the plants were grown practically by artificial light alone, still with the occurrence of excretion. In such experiments a degree of standardization of conditions may be achieved which is almost impossible if natural light is employed, and the investigation of factors of a non-climatic type is thus facilitated.

Prof. Wilson is endowed with a keenly critical mind, and does not hesitate to expose what seems to him to be faulty technique or reasoning. The result is that it is not unknown for him to be involved in disputes with other investigators, but

few will quarrel with the view he expresses here that controversy is in fact desirable and useful, provided it avoids the acrimonious. It is indeed a tribute to Prof. Wilson's energy and perspicacity, with which the reviewer was previously acquainted, that this volume should have been produced without appearing to affect the output of original papers from the Madison department. In a lighter moment, Wilson and Fred subjected the vast literature dealing with leguminous nitrogen fixation to mathematical analysis, and concluded that an annual publication of approaching one hundred articles was soon to be expected, though it is probable that this rather fearsome climax has now been postponed. In this latest monograph we have a substantial addition to the 1940 quota of literature, but one which will be of great use to a variety of investigators. G. BOND.

THE ENGINEER'S YEARBOOK

The Engineer's Year-Book of Formulæ, Rules, Tables, Data and Memoranda for 1941
A Compendium of the Modern Practice of Civil, Mechanical, Electrical, Marine, Gas, Aero, Mine and Metallurgical Engineering. Originally compiled by H. R. Kempe and W. Hanneford-Smith. 47th annual issue, revised under the direction of L. St. L. Pendred. Pp. xii+2778+lvii. (London: Morgan Brothers (Publishers), Ltd., 1941.) 35s. net.

ONCE again, despite all the difficulties associated with war-time publication, "Kempe" has appeared and to all external appearances differs in no respect from its earlier issues. There is more in this than mere sentiment, for the publication of "Kempe" has become an important annual occasion in the engineering world. Originally designed by H. R. Kempe, engineer-in-chief at the General Post Office, to be a work which, being carefully brought up to date year by year, should take its place as the standard book of reference in the engineering profession, it has in actual fact attained to this eminence and fulfilled the destiny planned for it.

The 1940 edition, being the first affected by the present War, was subjected to some major alterations such as the elimination of the section dealing with costs, which had been rendered useless by the new conditions. In its place, the mathematical tables were reinstated, and it is in precisely the same form as that of its immediate predecessor that the 1941 edition has been issued. Last year the demand, instead of being smaller than usual as might have been anticipated, actually proved to be enhanced by the changed conditions, thus confirming the need for such a publication and the reliance which engineers have come to place upon "Kempe". The range of information packed into its many pages is amazingly wide, and, being well documented and backed by the high reputation of the men who have contributed its various sections, can be relied upon to yield most of the established data such as may at any moment be required by a practising engineer in one or other of the branches enumerated in the bibliographical particulars given above.

Two minor omissions should be made good in due course. In the section on belt conveyors an empirical formula for the power required to drive a conveyor of this type includes a term representing the weight of the belt; but no information appears as to the weight of such belts. Further, formulæ are given for the approximate strength of wire and manila ropes, but for cotton ropes for there are no such data.

EVERYDAY CHEMISTRY

An Introduction to Chemical Science
By Prof. W. H. Hatcher. Pp. viii+423. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1940). 18s. net.

THIS book is based on a course of lectures which has been developed over a period of years by the author in an attempt to give to non-scientific students at McGill University a cultural appraisal of chemistry.

The book is divided into four main parts, namely, inorganic, organic, food and industrial chemistry, and contains a bibliography and comprehensive index. In the first part, an introductory account is given of the non-metals and their more important compounds, and this, quite rightly, is blended with an elementary discussion of solutions, colloids and the atom. A broad survey of both metals and non-metals is also given in three chapters which are devoted to the classification of the elements.

Part 2 provides a satisfactory introduction to organic chemistry, a special feature being the number of large and well-printed structural formulæ. The non-specialist is helped by the omission of detailed descriptions of preparations and properties, although this commendable feature is rather marred by the naming of too many complex organic compounds.

The section on the chemistry of foods, Part 3, should be of particular interest at the present time to both scientific worker and layman because the relative values of various foodstuffs are compared. The chemistry of digestion is explained, as also are some of the mysteries of the kitchen. An elementary account is given of the vitamins, and this includes an interesting table of an adult's requirements of vitamins and the weights of different foodstuffs containing these quantities. Incidentally, the figures in the table refer to the *daily* requirement of an adult, but the author has omitted to mention this fact.

The final section of the book, Part 4, gives a simple but interesting survey of industrial chemistry. The sources and methods of obtaining the raw materials are first described, and then elementary details are given of the chemical processes whereby these raw materials are made to yield metals, acids, ceramics, refined oils, etc.

This volume, which is printed in large type and strongly bound, should prove a valuable addition to any library. The intelligent layman and the sixth-form pupil on the non-science side will find much of interest in the book, while chemistry teachers will find useful material in it for the preparation of their general science courses.

A. C. C.

MEASUREMENT OF TEMPERATURE

A Manual of Heat and Temperature Measurement

Compiled by Robert L. Weber. Pp. vii+141. (Ann Arbor, Mich.: Edwards Brothers, Inc., 1939.) 2.85 dollars.

Temperature Measurement

By Robert L. Weber. Pp. x+172. (Ann Arbor, Mich.: Edwards Brothers, Inc., 1941.) 2.50 dollars.

THE interest of these volumes lies chiefly in the light which they throw on the methods adopted in a progressive American university to give a practical course to those who will afterwards use scientific instruments in their work. Each book is in two parts, the first an outline of the subject, the second giving the laboratory notes for about twenty experiments.

In the manual of heat and temperature measurement, Part 1 would strike an English student as far too scrappy to be of any value except for revision: in twelve chapters, of an average length of 6 or 7 pages each, the subject of heat is dealt with. Chapter iv, on the other hand, occupying 15 pages (including a full-page photograph of the outside of a potentiometer indicator), compensates for these defects by giving a much fuller, helpful and critical account of thermocouples and their uses than would be found in a British text-book. Subsequent chapters deal sketchily with the theory and well with the practice of radiation pyrometry and resistance thermometry. There are very good chapters indeed on recording pyrometers and on automatic control of temperature

Part 2 of either volume would offer suggestions to many teaching institutions. The whole outlook is practical, and the experiments are well chosen to illustrate principles and yet to introduce the student to instruments likely to be used in his subsequent career.

The later book, on the other hand, deals more thoroughly with its less extensive subject. The outlook is admirably practical, and there are tables of the properties of thermo-electric metals and of refractories, in addition to other data which make the book of value to the worker in heat, as well as to those in the student stage. All branches of temperature measurement—including the extremely low and the extremely high—are considered, and such matters as flame temperature are not overlooked.

The books have been photographically reproduced from typescript, presumably with the figures gummed on to the copy, and the result is pleasing. They are bound in a limp cloth which seems likely to withstand student handling, and would well repay perusal, if not by students, at any rate by those who plan their courses of instruction. Many of the figures lack any informative value, and some are too dark to show any detail, but a pair on p. 101 of the later work, showing interference fringes caused by heated streams of air, are magnificent.

In each book there is an appendix of tables, larger in the 1941 book than in its predecessor, noteworthy among them being a compact table of the E.M.F. of thermocouples every 2° from 0° to as high as 1720° C., and occupying no more than a page.

THE SUN AS A PRODUCER OF ENERGY*

By Prof. S. Chapman, F.R.S.

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Radiant and Gravitational Energy

THE existence of ionized layers in the earth's atmosphere is due to solar radiation, but in the *phenomena* of the ionosphere an entirely different cause plays a secondary part, namely, gravitation, exerted in the form of tidal forces, more by the moon than the sun.

The same two distinct causes provide the energy that electrical engineers develop and apply in so many ways. The sun's radiation is the chief source. Though engineering based on the direct use of the sun's heat is not yet practicable on any large scale, great use is made of past sunlight, stored up in the coal measures; and hydro-electric power comes from solar radiation of our own time, which raises water from the sea to the sky; it descends as rain, and some of this rain-water flows through turbines on its way from the highlands to the sea. A secondary source of energy is gravitational, namely, the sea tides, especially where these are magnified in narrow channels.

Solar Energy: the Gravitational Theory

Helmholtz thought that ultimately these two sources were the same—that the sun's radiation is derived from potential energy of gravity which the sun once possessed in much larger measure than it does to-day. In his view the sun was formerly a sphere of rare cool gas, far larger than now; its self-attraction caused it to contract, and as the outer layers 'fell' inwards or 'downwards' towards the centre, the gas within was compressed and its temperature rose. Thus the sun gradually became hot, from the centre outwards. When the heat had spread to the surface, the sun became luminous, and its transformed gravitational energy was poured out as radiation.

On the basis of this theory Lord Kelvin concluded that the sun could not have shone with its present brightness for more than about 20 million years, and that therefore the geological changes and the evolution of life on the earth must have been limited to this period. Impressed by his authority, some geologists accepted his estimate; others, more independent in mind and more confident in their own data, rejected it; we know now that they were right.

* From the earlier part of the thirty-second Kelvin Lecture to the Institution of Electrical Engineers, entitled "The Sun and the Ionosphere", delivered on May 8.

The Subatomic Source of Solar Energy

These two great men, Helmholtz and Kelvin, were dealing with a real and important feature of the sun's power supply, but perforce they missed the main point, which was beyond the science of their time. The present output of solar energy is not of gravitational origin; it is produced in the central region of the sun, from subatomic energy, by a special type of combustion or chemical reaction.

The fuel is hydrogen, and of this the sun has large reserves, comprising about a third of its mass. The product of combustion is helium.

Terrestrial and Solar Combustion

The solar combustion has interesting analogies with the burning of coal in a furnace, but in other ways it is remarkably different. In a coal furnace one carbon atom combines in successive stages with two oxygen atoms to form a complex molecule, carbon dioxide. The reactions are essentially of the form:

$$2C + O_2 = 2CO,$$
$$2CO + O_2 = 2CO_2;$$

and in the process energy is emitted in the form of heat. The burning begins only if the coal is first heated to a suitable temperature; its combustion then maintains this temperature.

The combustion in the solar furnace likewise produces one complex particle, a helium atomic nucleus, out of four simpler particles, in this case four hydrogen atomic nuclei; and in the process energy is emitted, mainly in the form of radiation of very short wave-length, namely, γ-radiation. The process begins only when the solar gas is raised to a very high temperature and density or pressure.

Herein lies the important part played by the gravitational contraction considered by Helmholtz and Kelvin; this produces the necessary temperature and pressure, twenty million degrees centigrade and ten thousand million atmospheres, near the centre of the sun. Thereafter the 'burning' of the hydrogen nuclei can maintain the temperature and prevent further contraction for thousands of millions of years, during which the sun radiates with at least its present brightness.

One may say that the solar furnace, like some types of internal combustion engine, was ignited

by compression. Helmholtz mistook the brightness and the radiation leakage during the initial ignition process (occupying only a few million years) for the main and much more productive process of energy generation from subatomic sources.

Ordinary Matter and Nuclear Crushed Matter

In a coal furnace the atoms and molecules that take part in the combustion are electrically neutral systems. They consist of small positively charged nuclei, containing almost all the mass, with an outer structure of light negative electrons.

In the central solar furnace the outer structure of all atoms is broken up; the gas therefore consists of free nuclei and free electrons. This 'crushed matter' is much more compressible than ordinary matter, and at the centre of the sun its density is about eighty-five times that of water.

Thus the combustible part of the central gas consists of hydrogen atomic *nuclei* (also called protons). These combine to form helium atomic nuclei (also called α-particles). The negative electrons present play no direct part in the combination.

The Main Reaction in the Solar Furnace

In a coal furnace oxygen is as essential to the combustion as the coal itself, and two atoms of oxygen (or one molecule) lose their separate existence for each carbon atom 'burnt'. The oxygen has an equal right with the carbon to be considered as fuel, though because it costs nothing we may ignore this.

In the solar furnace the fuel is hydrogen nuclei or protons. But these do not combine together directly; they are built up into helium nuclei in the course of a six-stage reaction involving a catalyst. The catalyst is a particle that undergoes a cycle of successive transformations but is left finally unchanged. At the outset of the helium-building reaction, the catalyst is an ordinary carbon nucleus ${}_6C^{12}$†; it undergoes four successive combinations, with one proton at a time; two of its intermediate forms are unstable, and undergo a spontaneous radioactive transformation, with the emission of a positive electron. The outcome of the fourth combination is a helium nucleus and an ordinary carbon nucleus as at first. The helium nucleus has been synthesized from the four protons, and the carbon nucleus is ready to start another such reaction cycle.

The equations of the six nuclear-chemical reactions are as follows, where I have added a + sign to the suffix as a reminder to the reader that the suffix indicates the number of elementary positive charges possessed by the particle; also e_+ denotes a positive electron carrying one positive charge, and of very small mass. In each equation the sum of the suffixes on the two sides are the same, and likewise the sum of the affixes; these equalities correspond to the conservation of charge and of mass.

2½ million years

$${}_{1+}H^1 + {}_{6+}C^{12} = {}_{7+}N_{13} + \text{gamma ray}$$

10 minutes

$${}_{7+}N^{13} = {}_{6+}C^{13} + e_+$$

50 thousand years

$${}_{1+}H^1 + {}_{6+}C^{13} = {}_{7+}N^{14} + \text{gamma ray}$$

4 million years

$${}_{1+}H^1 + {}_{7+}N^{14} = {}_{8+}O^{15} + \text{gamma ray}$$

2 minutes

$${}_{8+}O^{15} = {}_{7+}N^{15} + e_+$$

20 years

$${}_{1+}H^1 + {}_{7+}N^{15} = {}_{6+}C^{12} + {}_{2+}He^4$$

Preceding the line for each reaction a time is stated; this is an estimate of the time that elapses, under the conditions existing in the solar furnace, before the reaction occurs; Bethe, to whom this theory and these estimates are due, states that the times may be wrong by a factor 3 either way, except the shortest two, which are based on observation in the laboratory. The three long intervals illustrate the rarity of combinations at which two nuclei combine to form a single particle with the emission of the excess energy as radiation; this occurs only when the collision satisfies certain highly restrictive conditions. Hence the last combination, in which two particles, without radiation, result from the collision of two other particles, is far more probable than the possible alternative

$${}_{1+}H^1 + {}_{7+}N^{15} = {}_{8+}O^{16} + \text{gamma ray.}$$

The equations show that it takes a few million years for any one carbon nucleus, fertilized by four successive protons, to bring to birth one α-particle. If the birth-rate is high at the centre of the sun, it is because the number of carbon atoms and protons there is immensely great.

† The chemical nature of an atomic nucleus is determined by the number of (positive) elementary charges that it carries; for hydrogen, helium, carbon, nitrogen and oxygen nuclei these numbers (called the *atomic numbers*) are respectively 1, 2, 6, 7, 8. The nucleus is conveniently denoted by the appropriate chemical atomic symbol together with a suffix indicating the atomic number or number of positive charges (though either the number or the atomic symbol would suffice, as the atomic number uniquely determines the symbol). Thus the nuclei of hydrogen (a proton), helium (an α-particle), carbon, nitrogen and oxygen are denoted by ${}_1H$, ${}_2He$, ${}_6C$, ${}_7N$, ${}_8O$. The mass of the nucleus is not uniquely determined by the charge or atomic number; nuclei of different masses but the same charge are called isotopes. The atomic mass may conveniently be indicated by an upper integer affix, equal (very nearly) to the chemical *atomic weight*. Thus a proton and an ordinary α-particle are denoted by ${}_1H^1$, ${}_2He^4$, and the isotopes of carbon, nitrogen and oxygen that occur in the solar central reaction are ${}_6C^{14}$, ${}_6C^{13}$, ${}_7N^{13}$, ${}_7N^{14}$, ${}_7N^{15}$, ${}_8O^{15}$; of these ${}_7N^{13}$ and ${}_8O^{15}$ are unstable.

THE ENERGY PRODUCTION

The catalytic combination of hydrogen nuclei is enormously productive of energy. Whereas the ordinary combustion of 1 lb. of coal gives heat energy equivalent to 4¼ electrical units, the 'burning' of 1 lb. of hydrogen nuclei produces radiant energy equivalent to nearly 100 million electrical units.

Energy has mass, though only 1 gram to 25 million electrical units; hence the radiant energy produced from 1 lb. of hydrogen nuclei has a mass of 4 gm.; the mass of the resulting helium nuclei falls short of 1 lb. by this amount—a perceptible diminution.

Helios, the sun, is a power producer on the grand scale. Its heating and lighting output is nearly half a billion billion kilowatts (more exactly, $3{\cdot}8 \times 10^{23}$ kw.), and I use billion in its English sense, to signify a million million. The corresponding loss of mass is at the rate of 4 million tons per second.

THE OUTWARD STREAM OF RADIANT ENERGY

This energy is generated in the central solar furnace mainly as gamma radiation. This struggles upwards through the immense surrounding mass of overlying gas, ever cooler and less dense the farther from the centre. The radiation is continually degraded in frequency or increased in wave-length, and finally it leaves the sun with a spectral distribution corresponding roughly to a temperature of 6,000° C. It consists of electromagnetic waves the average frequency of which is still very high, nearly a billion kilocycles per second. As it reaches the earth and other distant consumers, it is highly directional.

SOLAR SURFACE PHENOMENA

In the upper layers of the sun the stream of outward flowing radiation energizes many surface phenomena on a grand scale. Of these the most evident are the sunspots and prominences. Much of the solar gas that we see raised above the surface in the form of prominences falls back again on to the sun, but some of it is expelled never to return. Thus the sun sends forth matter, as well as electromagnetic radiation, into the space around it. The matter, in the form of clouds or streams of rare gas, is a partner with the solar wave radiation in ionizing the earth's outer atmosphere.

ENERGY SUPPLY TO THE EARTH

Of the sun's majestic outpouring of radiant and material (kinetic) energy, all but a tiny fraction is lost in the depths of interstellar space. The father Helios scatters his riches abroad with grand prodigality, and his children the planets intercept only the merest scrap of their patrimony. Our mother earth receives less than a thousand millionth of the parental output (more exactly, the fraction is $4{\cdot}5 \times 10^{-10}$). Yet her income of over 170 billion kilowatts is not small.

All this income she spends, and perhaps a little more, drawn from her own reserves. Very little of her income can she store up for the future. From one point of view, the history of the earth since she became a separate planet is largely the story of the spending of her solar income.

INTERACTION OF VITAMINS A AND E

BY A. W. DAVIES AND DR. T. MOORE
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ONE of the most noteworthy properties of vitamin A is the extent to which it can accumulate in the liver. When the dietary intake is liberal, sufficient vitamin may be stored to meet ordinary requirements for a theoretical period of about a hundred years[1]. Some years ago we began experiments to find whether during a subsequent deficiency these large reserves would in practice be preserved and used up economically at a rate corresponding with physiological requirements, or whether they would be dissipated at an unduly rapid rate. In our first experiment a rapid dispersal of the vitamin A reserves was observed[2]. We emphasized, however, that this result was exceptional, since in earlier work large reserves had been found in the livers of rats after prolonged restriction to deficient diets[3].

For several years we tried to repeat, and explain, our observations on the rapid loss of vitamin A, but with unsatisfactory results. The influence of the exact nature of the basal diet was specially considered, and many minor modifications were made without affecting the rate of disappearance of the vitamin. Eventually a clue was obtained from an unexpected direction when it was found that the vitamin A reserves of rats which had been kept on a diet deficient in vitamin E were much lower than those of animals receiving equal amounts of vitamin A together with supplements of vitamin E[4].

Further unpublished experiments on this point

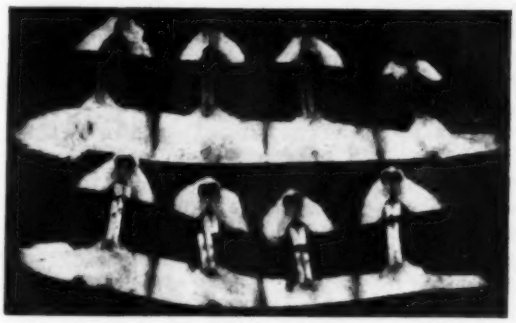
have shown that the effect in vitamin E deficiency does not lie entirely in the inability of the liver to absorb vitamin A, but also in a decreased power of retention after absorption. In the experiments to be described we have found that, under suitable conditions, deficiency of vitamin E may lead to acute secondary deficiency of vitamin A. The exhaustion of the reserves in the liver has been established directly by chemical tests. Further indirect evidence of secondary deficiency of vitamin A has been found in the appearance in the rats deficient in vitamin E of a dental abnormality hitherto ascribed to primary deficiency of vitamin A.

During a preparatory period of several weeks, young female albino rats were given an adequate mixed diet, supplemented by large doses of halibut liver oil. At intervals some of the animals were killed, and the reserves of vitamin A in their livers were estimated by the antimony trichloride method. When large reserves had been accumulated the animals were divided into two groups. Both these groups now received a basal diet deficient in both vitamins A and E (casein, Glaxo extracted 20 per cent, sugar 70 per cent, lard 5 per cent, salt mixture 5 per cent plus dried yeast 10 per cent, Radiostol, for vitamin D, 1 drop per rat per week). One group was given doses of vitamin E, in the form of 1 mgm. weekly of synthetic *dl*-α-tocopherol acetate. The other group had no vitamin E. Animals from each group were killed at intervals, and the vitamin A reserves estimated. The results obtained are shown in the accompanying table.

Days on diet deficient in vit. A and E	Vitamin A Reserves (I.U.) + vitamin E	− vitamin E	Notes
0	15,000		Rats killed after prolonged dosing with halibut liver oil before the remainder were restricted to a diet deficient in vitamins A and E
	15,000		
	15,000		
	22,500		
	22,500		
	30,000		
	mean 20,000		
28	15,000	15,000	Uteri of − E group still normal in colour
	18,000	15,000	
	30,000	18,000	
	37,500	18,000	
	mean 25,000	mean 16,500	
91	9,000	3,700	Uteri of − E group light brown
	12,000	4,500	
	15,000	4,500	
	15,000	6,000	
	mean 13,000	mean 4,700	
222	3,750	5	Uteri of − E group dark brown, teeth white
	6,000	6	
	6,000	9	
	7,500	15	
	mean 5,800	mean 9	

N.B. Growth was slightly more rapid in the + E than in the − E group. The mean initial weight of the + E rats which survived 222 days was 132 gm., the final weight 212 gm. The mean initial weight of the corresponding − E rats was 139 gm., the final weight 171 gm. During the last 100 days of the experiment the − E rats declined slightly in weight, and the fat reserves at autopsy were sparse.

In both groups the rate of loss of vitamin A exceeded that calculated from the presumed physiological requirement. An allowance of 10 I.U. per day should be sufficient for rapid growth in adolescent rats. On this basis not more than about 2,000 I.U. should have been used up in the animals kept on the deficient diet for 222 days, as compared with a minimum actual loss of 14,000 I.U. There was, however, a consistent difference between the two groups. At all stages of the experiment the vitamin A reserves of the rats given tocopherol were greater than those of rats which had no vitamin E. After restriction to the deficient diet for 222 days the reserves of the animals having tocopherol were still high, the mean total reserve being 5,800 I.U. The reserves of the untreated group were too low for accurate measurement, the mean being 9 I.U. The faint traces of colour given by the liver oils of this group, moreover, were not of the usual bright blue shade but a dull purple, similar to that given by preparations of vitamin A after partial destruction by oxidation. It is therefore doubtful what proportion of the colour can be attributed to unchanged vitamin A.



TOP ROW, + VITAMIN E, NORMAL TEETH; BOTTOM ROW, − VITAMIN E, WHITE TEETH

At autopsy evidence of vitamin E deficiency in the rats not given tocopherol was obtained by inspection of the uteri. In the groups killed after 91 and 222 days of deficiency the brown discoloration described by Martin and Moore[8], which is characteristic of deficiency of vitamin E in the rat, was always observed. The uteri of animals protected by tocopherol were all normal in colour.

Another striking difference between the two groups was seen in the teeth, which were of the normal brown colour in the group given tocopherol, but almost white in the untreated group (see accompanying illustration). Whitening of the teeth in vitamin A deficiency has been studied by several investigators[6,7,8,9]. According to H. Mellanby[10] the changes can be explained as arising primarily from a metaplasia of the epithelial cells of the enamel organs, which leads to secondary changes in the odontoblasts and dentine. If this conclusion is accepted, and the relation between

whitening of the teeth and deficiency of vitamin A is regarded as specific, it is clear that the appearance of this abnormality in the untreated group affords additional evidence of the occurrence of secondary vitamin A deficiency. In our experience however, partial whitening of the teeth may occur in rats which are deficient in vitamin E, but which still have considerable reserves of vitamin A in their livers. We have also occasionally observed brown teeth in rats which have died from deficiency of vitamin A. It may possibly be better, therefore, to regard this lesion as a common effect of deficiency of either vitamin.

Sections of the tracheæ of the rats not given tocopherol were examined, but only in one instance was the normality of the epithelium open to question.

In the above experiment we have achieved the apparent paradox of preventing deficiency of one vitamin by the administration of another vitamin. In the absence of full data on the effect of deficiency of other vitamins we cannot decide how far the role of preserving the vitamin A reserve is peculiar to vitamin E. We know, however, that the vitamin A reserves are not much reduced in deficiency of the vitamin B complex[3] or in prolonged deficiency of protein so severe as to cause emaciation and complete cessation of growth in young rats[4]. Some support for the possibility of a specific interaction between vitamins A and E may be derived from a consideration of their chemical properties. The tocopherols are higher substituted members of the class of hydroxy-aromatic substances of which hydroquinone is a lower and less hydroxylated member. This substance is often used for stabilizing solutions of vitamin A in fats. The tocopherols may possibly have a similar action under physiological conditions.

The present results explain the rapid loss of vitamin A reserves observed in our early experiment[2] if we assume, as seems highly probable, that the basal diet used on that occasion was unintentionally deficient in vitamin E. Our knowledge of the role of vitamin E in human nutrition is too scanty to allow speculation as to whether the present findings have any clinical significance. From estimations of the vitamin A reserves of humans at autopsy, however, we know that secondary subnormality of vitamin A is common and sometimes severe. Thus the medium reserves for forty cases of chronic nephritis was found to be 25 I.U. per gm. of liver as compared with 220 I.U. per gm. in accidental death. Any factor, such as vitamin E deficiency, which causes secondary vitamin A deficiency in experimental animals must be worth consideration in the investigation of human diseases in which the reserves of vitamin A are known to be reduced.

SUMMARY

(1) In rats restricted to a diet deficient in both vitamins A and E the reserves of vitamin A were used up much more rapidly than in control animals given *dl*-α-tocopherol.

(2) Prolonged deficiency of vitamin E led to secondary deficiency of vitamin A, as indicated by the disappearance of this vitamin from the liver. The deficient rats also developed the whitening of the teeth which is generally held to be an effect of deficiency of vitamin A, but which may perhaps be considered a common result of deficiency of either of these vitamins.

Our thanks are due to Dr. L. J. Harris for his valuable criticism, and to Roche Products Ltd., for gifts of *dl*-α-tocopherol.

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FEEDING DRIED NETTLES TO LIVESTOCK

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THE quantity of stinging nettles grown unwillingly throughout Great Britain must amount to a very considerable weight of material each year. What is its food value? According to average figures for the chemical composition of dried nettle leaves, they compare very favourably indeed with hay of good quality and would appear to be as good as clover, lucerne or sainfoin in their content of protein, while the fibre is generally shown to be lower in nettles than in hay, even when the latter is of a very good grade.

Furthermore, digestion trials have shown that nettle leaves are highly digestible and in this respect also rank with the best species and grades of hay. Although fibrous in character, they are nevertheless well utilized by animals which

normally have only low powers of digesting fibre, such as the pig, fowl and rabbit. Nettles mixed with straw chop have been used effectively in feeding cows and horses, but the amounts available are usually better suited for use with small livestock, and it is with these that experiments have usually been made. Such experiments were carried out in Germany[1] and gave results for digestibility which were somewhat better with nettles than with lucerne hay, and conspicuously better than with meadow hay. The figures for the total organic matter digestion coefficients were 63, 61 and 47 per cent respectively, while the comparison was even more favourable for the separate items of protein and fibre.

As these digestion trials were carried out with rabbits, even more favourable results might be expected with ruminants[2], since they are specially adapted for digesting fibrous foods. Judged by these results, and assuming that livestock will eat nettles freely, it would seem desirable that more use should be made of this common weed as fodder—and indeed it might even be better worth growing for hay than inferior grass. There seemed at least to be a sufficient warrant for the small-scale tests described below, which were carried out in the Rabbit Department of the National Institute of Poultry Husbandry.

Palatability of Nettles (Dried)

A few tests of the palatability of nettles may first be noted: The rabbits were kept in sheds with grass runs adjoining, where the grass was closely grazed until there was none left in the summer time and additional green food had to be fed. Even when the runs were bare of grass, the animals did *not* eat the stinging nettles when the nettles were growing even when they were very short, young and leafy. This result was obtained each year, and was checked in the past season with thirty more animals; these animals were kept short of green food, but only slight nibbling could be induced on a few of the growing nettles. The nettles were then mown and left on the ground, where they remained, and normal feeding was resumed. During the following month all the dried-up nettles were eaten, including the stems. (It will be noted that this is exactly the reverse process from inducing stock to eat the common thistle, for thistles should be young and tender if they are to be eaten by stock.) More nettles were cut and made into hay before reaching the flowering stage; less turning was necessary than is usual with hay, owing to their stalky nature when cut. Later, the dried nettles were fed to ten adult rabbits in hutches, and although at first two refrained from eating them for two and for three days respectively, they all ate them readily after the first few days. Feeding continued as with normal hay and they were evidently a palatable food.

A further supply of stinging nettles was cut, but as the weather then seemed unsettled and rain likely, these nettles were carted indoors about the third day. These were fed to ten young hutched rabbits at the half-grown stage, but this lot practically refused them after nibbling the first few pieces. The rest of the ration was then curtailed, but none of these young animals would clear up the nettles. The only noteworthy difference in this nettle hay was that it was cut later and carted before it was as well made as could be wished for; it was, however, a good green colour. When this was handled, it gave a decidedly tingly or irritating sensation; that is, it retained some of its sting, which had practically disappeared in the better-made earlier-cut nettle hay which had been kept ten days or more.

Experimental

With the guidance of the foregoing preliminary observations, an experiment was started with nettles cut and dried for 3–4 weeks: twenty young rabbits, approximately two months old, were divided into two similar groups and fed for eight weeks on a mixed diet of greenfood, roots, mash and hay. The first group, acting as the control, received the usual grass hay available from poultry runs. This was mainly composed of the coarser grasses including cocksfoot, and generally of a low grade. The other group was fed on a similar ration except that grass hay was replaced by an equal weight of dried stinging-nettles—after they had lost their sting—cut before the flowering stage. Care was taken to use nettles which were free from grass or weeds. The quantities of food were kept level in both groups, although it was soon noticed that the nettle group consumed their hay quicker than the lot on the coarse grass hay. As the stock grew older, the amount of food was increased but only to the level at which the grass hay group would clean up their ration. The amount of foodstuffs used daily for these small youngsters started off at a daily average per head of: 0·71 oz. of hay, 2·64 oz. kale and swedes and 1·48 oz. of dry mash. Water was drunk at the rate of 0·10 pint per head daily. The quantities of food were increased in the following month to 1·03 oz., 3·09 oz. and 2·01 oz.; this was the rate at which the controls cleared up their daily allowance but appeared to be less than the nettle group would have taken if allowed an unrestricted diet. In the following weeks it became even more noticeable that the nettle group finished its

food more quickly than the grass hay group. There was a tendency for the latter to be troubled with intestinal obstruction when very rank hay was used.

The animals were weighed at regular intervals, and at one month after this feeding started there was a perceptible difference in the condition of the two groups, which became more evident as the length of the feeding period increased. In the early weeks, body condition and coat were rather better on nettles and, as the system continued, the live weights illustrated the definite advantage of feeding nettle hay compared with coarse grass hay, as the nettle-fed stock weighed on the average 8·7 per cent heavier than the controls. If expressed as a percentage gain over the controls, it amounted to 17·0 per cent. They were very hard and firm when handled, and tighter in the skin than controls.

Data for the two groups are set out below:

BODY WEIGHT AND CONDITION (OZ.)

Group:	Grass Hay	Nettle Hay
Initial live weight, average	27·10	27·10
Final live weight, average	55·30	60·10
Average live weight gain	28·20	33·00
Difference in gain, as percentage of gain made by control	——	17·02
General body condition, at final weighing	Quite good	Excellent
General coat condition, at final weighing	Moulty and rough	Moulty, but glossy and silky textured

The quicker growth and heavier weights of the nettle-hay group showed a further advantage in the ratio of food consumption per pound gain in live weight. There was a saving of 15·56 per cent in the amount of concentrates used for each pound of live-weight gain when fed with nettle hay. The glossy coat produced by the nettle feeding is of special interest, since the same effect has been claimed for nettles when fed to horses.

Acknowledgement is made of the advice and assistance received from Dr. Charles Crowther.

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OBITUARIES

The Right Hon. Lord Cadman, G.C.M.G., F.R.S.

THE very complete biographies of the late Lord Cadman, who died on May 31 at the age of sixty-three, that have appeared in the Press render it unnecessary to deal with his multitudinous activities here.

It is rather the intention of the writer to throw into relief his achievements as a man of science, and it is more than likely that it is just this aspect of his life that Lord Cadman would have wished emphasized.

After more than twenty-five years of close association with him, it is apparent that the scientific approach to industrial problems had assumed an overwhelming importance. In all the wide gamut of the petroleum industry from the initial geophysical exploration, the geological demarcation of oil-bearing formations, the technology of drilling, the corrosion of pipe-lines and plant and ships to the chemistry of refining processes, his fluid and prehensile mind was fully occupied and extended. There was probably no one man of our epoch with the same encyclopædic knowledge and, what is more important, the same wide and active sympathy with those who were associated with him as his scientific colleagues.

In his younger days Cadman was primarily a 'coal' man. At the age of twenty-six he was appointed H.M. Inspector of Mines for East Scotland and very shortly after was seconded to Trinidad as Government mining engineer. It was in this position that he encountered the multitudinous problems of the petroleum industry. Returning to England in 1907, he became professor of mining in the University of Birmingham, a post he held for thirteen years, during which time he founded the first school of petroleum technology to be established in the Empire and was professor emeritus at the time of his death. It was in Birmingham that his close collaboration with his old friend, the late Prof. J. S. Haldane, began, and a fruitful series of investigations into various mine hazards was accomplished. In the War of 1914–18 he was intimately concerned in the problems of trench warfare and of gas protection. Ultimately he was made director of the Petroleum Executive and chairman of the Inter-Allied Petroleum Council. He co-ordinated all oil supplies both for the United Kingdom and the Allies. During these busy years and for long afterwards, he retained his interest in the scientific and technical aspects of industry, served on innumerable commissions and committees and occupied the presidential chairs of the Institute of Petroleum, the Institute of Fuel and the Institute of Mining Engineers.

He received the medals awarded by the latter two bodies. He served on the Advisory Council of the Department of Scientific and Industrial Research of the Privy Council, the Safety in Mines Research Board, the Coal Advisory Council and the Prime Minister's Economic Advisory Council. He was a member of the Fuel Research Board from 1923 until his death, except for a short break of four years. During the time he was a member of the Board, he was intensely interested in the work and took a prominent part in the discussions in the Board. Although he was so intimately associated with oil, his association with the coal industry had left him with real sympathy with the subject, and he never hesitated to use his influence to further the scientific application of coal. He continually advocated the complete gasification of coal so that cheap gas could

be made accessible in large volumes in Great Britain. He also took a great interest in the production of motor spirit from coal by the hydrogenation process. The coping stone of his scientific career was placed only last year by his election to the fellowship of the Royal Society.

As one of his oldest colleagues, the writer wishes to stress Cadman's perpetual insistence that no industry can flourish that is not soundly based on truly scientific foundations. In the Anglo-Iranian Oil Company he fostered research. He was responsible for the creation of the largest petroleum research station in the Empire and one that will bear every comparison with corresponding organizations abroad. He was deeply sensible of the need of the latest and best scientific advice. He supplemented the efforts of his own staff with those of highly skilled and eminent advisers. He continually visited the laboratories and took the keenest interest in the welfare and well-being of his staff. In return he was rewarded by a constant stream of invention, discovery and development. A. E. DUNSTAN.

Dr. R. Campbell Thompson, F.B.A.

REGINALD CAMPBELL THOMPSON died of heart failure after coming off duty with the Home Guard on the night of May 23. He was the last representative in England of a phase of Assyriology which converted that study from a discovery into a science. When he was a boy at St. Paul's, he was attracted by the results attained by the early Assyriologists during the heroic days which had opened with the measured judgment on translations submitted by four different scholars in 1842, by a committee which did not profess to understand the text translated. By the time he reached Caius College, Cambridge, the *epigoni* had been busy for some fifteen years producing grammars, dictionaries, catalogues of tablets; the exciting work of decipherment and interpretation on the lines of Sir Henry Rawlinson, George Smith, Oppert and Sayce was becoming a science and was a subject favoured by German, but not by English, or even French, universities. When he entered the British Museum in 1899, already well equipped for Assyriological studies, the ground had been prepared for the classification of Babylonian and Assyrian texts, for methodical publication of texts by classes and for the codification of results.

For forty years Thompson contributed, sometimes with the brilliant success of the pioneers he most admired, but also by steady and laborious work, to the new conditions of his chosen subject. Between 1900 and 1908 there appeared in the official publication of the British Museum copies from his pen of Babylonian syllabaries, magical incantations against evil spirits, Babylonian letters of the late period, each class of document arranged after examination of great numbers of tablets and fragments, all the copies in beautiful script, the standard of accuracy remarkable. In addition to this great output, he edited, in private publications, texts dealing with astrology, magic and social life. In each of these branches, more particularly in astrology, his work was of outstanding importance, for he was able to discard much worthless nonsense that had been written on the subject and produce an interpretation of the astronomical phenomena involved, on which subsequent studies have been firmly based. He then turned to the study of comparative religion; his volume on "Semitic Magic", though affected by prejudices and questionable preconceptions, contains information not to be found elsewhere, which ought not to be neglected by younger scholars as it has been.

After the break caused by travel when he left the British Museum, and by service in Intelligence during the War of 1914–18, Campbell Thompson's principal scientific work was concentrated on the publication and interpretation of those Assyrian texts which contained prescriptions for the sick, in the form of omens, or recipes for making glazes or glass. After publishing the original texts of most of the documents himself, he undertook the strenuous labour of classifying and interpreting the names of plants and stones, using for this purpose the scattered references in the wide range of cuneiform literature, and applying comparative material that required minute study. In two books, the "Assyrian Herbal" and the "Dictionary of Assyrian Chemistry and Geology", he provided two model works for the history of science, which have indeed been heavily drawn upon by general writers on that subject. The collection of material is beyond praise, the interpretations suggested always reasonable, most often correct, sometimes brilliant in their insight. These two works constitute Thompson's great contribution to humane learning, and it is the more to be regretted that owing to circumstances he was not able to see a printed edition of his "Assyrian Herbal" to press; the fitting tribute to him would be that such an edition should yet appear.

He was a man of many-sided interests, of boundless energy and enthusiasm. His chapters in the "Cambridge Ancient History", vols. I–III, give the liveliest, most human picture of the ancient Babylonian civilization yet written. His translation of the Gilgamesh Epic, following an excellent edition of the text which involved a new examination of the British Museum collections, betrays the same zest in the human quality of the story. As a traveller, he loved the manners and methods of the past, and aimed at describing his experience in the words of the past, as in "Pilgrim's Scrip" (1915). Excavations at Carchemish, at Wadi Sarga in Egypt, at Nineveh, were an adventure, conducted in that spirit to shock the over-serious or dull-witted. An undeciphered script, the Hittite hieroglyphs, he attacked with an optimism justified in that he was able to produce results still accepted in part. Prize poems and anonymous novels were part of his activities, and so were yachting and games.

Thompson was a fellow of Merton, Shillito reader in the University of Oxford, and fellow of the British Academy. No one who met him could fail to recognize his sterling qualities, honesty, energy, disinterested devotion to his subject. SIDNEY SMITH.

NEWS AND VIEWS

The British Council Science Committee

THE British Council was formed in 1934. Under its charter, its object is defined as the promotion of a wider knowledge of Great Britain and Northern Ireland, and the English language abroad, and the development of closer cultural relations between the United Kingdom and other countries. The Council has already established many institutes abroad, and has active departments concerned with fine arts, music, drama, education, films, foreign visitors and students, books and other subjects. It has now formed a Science Committee under the chairmanship of Sir William Bragg. The other members of the Committee are Prof. P. M. S. Blackett, Prof. J. D. Cockcroft, Sir Robert Robinson, Dr. C. F. A. Pantin, Sir Edward Mellanby, Surgeon Rear-Admiral Gordon Gordon-Taylor, Sir William Larke, Sir Edward Appleton, Dr. A. P. M. Fleming, Mr. C. D. Le Maistre and Prof. R. V. Southwell.

Mr. J. G. Crowther has been appointed secretary of this Committee. Mr. Crowther is well known as the scientific correspondent of the *Manchester Guardian*, and has for many years been associated with the publication of scientific books. He is the author of fourteen general books on science, the most recent being "The Social Relations of Science". His book on "British Scientists of the Nineteenth Century" is also well known. Mr. Crowther has visited and written about many scientific institutions in Europe and America, and in 1937 he was invited by President Conant to deliver a course of lectures at Harvard University on the history of American science.

Bedford College, London: Chair of Zoology

PROF. H. MUNRO FOX, who succeeds the late Prof. C. L. Boulenger as head of the zoological faculty at Bedford College, London, has had a varied career. He was educated at Brighton College and Caius College, Cambridge, proceeding to the Imperial College of Science and Technology, London, as lecturer in 1913. In 1914, he enlisted in the London Mounted Brigade, in which he served until 1919, for the most part in Egypt and Palestine. In 1919 he became lecturer in biology at the School of Medicine, Cairo, leaving in 1923 to become demonstrator in zoology at Cambridge. He was already a fellow of his College and in the following year he was elected to the Balfour studentship. He then proceeded to the Suez Canal, where he investigated the fauna and conditions in relation to migrations between the Mediterranean and Red Seas, a survey which it is hoped may be repeated in 1950. The lunar periodicity in the breeding of marine animals was his discovery. In 1926 he started the *Biological Reviews* of the Cambridge Philosophical Society, of which he is still editor.

Prof. Fox's chief interest throughout his career has lain in the comparative physiology of respiration, the pigments concerned, the effects of environmental conditions, the circulatory system and respiration, especially in the marine worms. Later he investigated the properties of chlorocrurin, which has a low oxygen affinity, and its physiological relationships to the queer animals in which it is found. In particular, he was concerned with the serpulids and sabellids, in which he discovered an in-and-out circulation comparable to that which Galen supposed to exist in the human body.

Royal Anthropological Institute Awards

THE Rivers Memorial Medal for 1941 has been awarded to Dr. Diamond Jenness, ethnologist in the National Museum of Canada, for his work among the Eskimos of Arctic America. Dr. Jenness is a graduate of the Universities of New Zealand (1908) and Oxford (1911), and in 1935 was made an honorary Litt.D. of the University of New Zealand. Before being appointed in 1913 to his present post in the National Museum of Canada, he carried out field work in Papua; his principal work, however, has been among the Eskimos and Indians of North America. He took part in the Canadian Arctic Expedition of 1913–18, when he visited the Copper Eskimos; since then he has studied the Sarcee Indians of Alberta, the Carrier, Sekani and Coast Salish tribes of northern British Columbia, the Ojibwa Indians of Ontario, and has made expeditions to the Bering Straits and to Newfoundland.

The Wellcome Medal for 1940 has been awarded to Dr. Audrey I. Richards for her essay on "Bemba Marriage and Present Economic Conditions". After studying at London and Cambridge, Miss Richards was appointed lecturer in social anthropology at Bedford College for Women, and later she went to the London School of Economics. During 1934–38 and until recently she held a similar post in the University of the Witwatersrand. Dr. Richards has been especially interested in social anthropology of the functional type, particularly in psychological problems and in general problems of nutrition. In pursuit of her studies, she has made numerous expeditions to tribes in Northern Rhodesia.

Mr. Roosevelt and Oxford

Two striking parallel ceremonies took place at Harvard on June 19. Lord Halifax, British Ambassador to the United States, was given the honorary degree of doctor of law of Harvard University, and in his capacity of chancellor of the University of Oxford, he presided at a special Convocation, in which he conferred the degree of D.C.L. on President Roosevelt. Mr. Roosevelt was advised, on account of his temporary indisposition, not to make the journey from Washington to Harvard, but his friend and military *aide*, General Edwin Watson, represented him and delivered a stirring message of acknowledgment. In the Latin diploma granting the degree prepared for the occasion, reference was made to the

heartening words with which Mr. Roosevelt has encouraged the defenders of liberty and to the material aid which he has given, and in ever-increasing measure is giving, to secure the defeat of lawlessness and aggression among nations, and to the stand he is making for liberty, humanity and law. Mr. Roosevelt's message mentioned the historic precedent of this special Convocation, expressing his pleasure that it "does so in the great cause of preserving the free learning and civil liberties which have grown stone upon stone in our lands". He concluded with the epigrammatic words: "We and all others who believe as we do would rather die on our feet than live on our knees."

A Dynamic Civilization

In his presidential address "Industrial Progress, Whither and Why", before the Birmingham Metallurgical Society on March 8, Mr. C. H. H. Franklin pointed out that we are living in an epoch of dynamic change, and that whether we evolve into the finest civilization humanity has known or relapse into barbarism comparable with the Dark Ages of Europe after the fall of Roman civilization, is the principal issue. He urged that the future of industry, as of nations and of men, is being decided on the fundamental issues of free mutual co-operation, versus exploitation and compulsion. The organization of an animal or human structure provides valuable clues to the organization of our communal life, and he stressed the necessity of developing a team spirit in our industries and the concept of service of human and social needs if we are to extirpate the cancerous growth at present spreading in Europe and Asia and threatening all humanity. We need also to develop the technique of generating appropriate financial currents for human utility and service instead of its enslavement.

Mr. Franklin referred to the necessity of clarifying our concepts of the laws of growth, of change and of evolution, and of obtaining correct and not superficial answers to the questions of what we are making things for or why we are doing them in our present way. An individual or organization which reaches a stage where its sole concern is continuing its own existence is ripe for decay and dissolution. A great industrial city should display relics of its own industrial growth and models which show what has been and can be done. The deficiencies of past utensils have stimulated the desire and attempt to develop new materials which avoid these drawbacks. Referring to the new materials placed at our disposal by metallurgical progress, Mr. Franklin emphasized the importance of cooking utensils, and suggested that the most appropriate materials for such vessels are metals which, if attacked, only yield salts naturally present in the human body, or metals quite immune from attack. He also referred to the way in which care of cleansing should govern the choice of forms, and to the possible future of magnesium alloys in household tools. He looked forward to a world in which good things are efficiently prepared and craftsmen take a worthy place, the right properties being selected for a given purpose, and incorporated in worthy design, in which human personality or individuality is not cramped or repressed. By utilizing in this way for all our purposes the new resources at our disposal and working in this spirit of evolution, we can build up the harmony of life which our civilization is missing.

The Position of the Jews

In his pamphlet "The Jewish Question" (Oxford Pamphlets on World Affairs, No. 45. Oxford: Clarendon Press. 3*d*. net) Mr. J. Parkes points out that the Jewish problem arises from two sources: the Jewish tradition, which has inculcated in Jews the need to keep themselves separate if they would survive as Jews, and Jewish experience at the hands of the peoples among whom they have lived. Mr. Parkes shows how Jewry has been unfairly identified with all the malpractices of modern commerce and industry and the way in which prejudice, by embittering Jewish experience, has accentuated the minority problem which Jewry might normally present. Modern anti-Semitism has made the problem acute through two main factors: the persecutions in Tsarist Russia at the end of the nineteenth century, which led to the flooding of Western Europe and America with several million Jewish refugees from a totally different level of culture; and the fever of nationalism which spread over the world after the War of 1914–18 and made life difficult for all minorities.

Mr. Parkes considers that the accurate and scientific studies of the question we possess, and our knowledge of the effects of past experience, warrant the view that with planning and co-operation there is nothing in the Jewish problem which need cause pessimism or despair. He suggests that in the light of experience of the last twenty years, a minority is entitled to a communal organization, recognized as a public body, and with control over primary education and teachers' colleges, charitable foundations, and cultural activities, as well as to religious freedom and authority in religious matters where the minority is also a religious minority. On each point the majority has certain rights, for example, in regard to language. Among the Jews themselves, assimilation with their countries of adoption, or the foundation of a Jewish national home have been the main programmes proposed and followed. The basic problem confronting Jews lies in the view which they take of their status: whether they wish to be considered merely a religious minority or a separate national minority. The ultimate problem of Jewry is the rediscovery and reassertion of the fundamental spiritual and social realities of Judaism, to which both assimilation and Zionism are capable of offering soils already prepared.

Bread Flour

Prof. J. Reilly, professor of chemistry in the National University of Ireland (University College, Cork), has produced a booklet entitled "Our Daily Bread" which is particularly interesting at the present

time in view of the desirability of making the British Isles less dependent on imports of wheat for its 'daily bread' (Cork : Forum Press. 2s.). He advocates the increased growing of rye, which is hardier than wheat and can be grown on poorer soils, and points out also that oaten and barley flour may without any dietetic disadvantage be used to eke out supplies of wheat. Growers of potatoes should be encouraged to set aside a portion of the crop for the production of potato flour, which is able to furnish us with our carbohydrate needs. It is interesting to note that flour was so scarce in England in 1800 that the Brown Bread Act was passed forbidding the use of pure white wheaten bread, and at this time flour was generally a mixture of equal parts of wheaten and rye flour. Wholemeal bread, of course, in contrast to white bread, contains comparatively large amounts of vitamins and minerals, although this is not the whole of the story.

Origin of Cultivated Water-Melons

ACCORDING to Dr. Orland E. White of the University of Virginia, Africa, not America, is the native land of the water-melon. Speaking before the meeting of the Virginia Academy of Science, he told of recent researches at the Blandy Experimental Farm, which throw new light on the ancestry of this plant. Water-melons were not known at either the Epicurean feasts of ancient Greece or the Lucullan banquets of Rome. Not until the great age of exploration in the sixteenth century do they appear in the world picture. Dr. White is of the opinion that the Portuguese, pushing southward along the coast of Africa, became acquainted with the ancestors of modern water-melons growing wild in South Africa. They soon transferred them to their colony of Brazil, where the Indians promptly adopted them and added them to their own array of crops. Thus the myth of an American origin of water-melons came into being.

Dr. White has obtained seeds of several strains of these small wild South African melons, which have little enough resemblance to the monsters of the modern melon patch. He also has under cultivation stocks of a bitter variety of melon, known as the colocynth, familiar to the ancient Egyptians and other Mediterranean peoples, but used by them only as medicine. He has made many crossings between them and modern cultivated water-melons, some of which may eventually prove commercially valuable.

Phenology of 1940

WITH commendable promptness, the fiftieth Phenological Report of the Royal Meteorological Society, covering 1940, has just been issued despite war-time difficulties making it impossible for the executive committee to meet since the last report. With the exception of a small amount of introductory text, the report consists of a series of tables and diagrams, as has been its increasing trend in recent years. It has the observations of 288 phenological observers in the British Isles, compared with 385 in 1939. The publication of full meteorological details is still restricted, but it includes the events of the historic cold spell early in 1940, probably the coldest January for a hundred years and the sunniest for fifty years. The marked lateness of plants and insects caused by the cold opening of the year gave place to considerable earliness which mainly persisted from the end of April, with a succession of warm, mild spells, and the beauty of spring and early summer was enhanced by the simultaneous occurrence of normally early species which had been retarded and the normally later species which were brought forward.

This recovery also applied to crops, although some autumn-sown cereals failed to survive the winter. The droughty conditions in May, June, and, after a cool showery July, again in August and early September, had an interesting effect upon the grass ; in the north-west the assessed condition remained between 77 and 78 per cent throughout August, whereas in the south-east it deteriorated from about 77 per cent to about 56 per cent, during which period the rainfall was about 30 per cent of the average in the north-west but only 3 per cent in the south-east. Indigenous insects are unlikely to have been affected so much as indigenous birds, which, however, had a favourable nesting season after so hard a winter. Migrants arrived at dates not far from average in the south but somewhat later in the north, while the only large-scale insect immigration was that of the large white butterfly (*Pieris brassicæ*). The comparative earliness of the north-west district is shown in the plant and insect diagrams, in advance of the south-east up to May.

Design of Wire Networks Carrying Radio Programmes

IN the *Bell Laboratories Record* of April there is an instructive paper by A. E. Bachelet explaining some of the difficulties encountered when designing wire networks over which radio programmes are transmitted. These in America often form extensive systems with broadcast stations or studios in most of the larger systems interconnected by high-quality circuits employing amplifiers. The transmission over these circuits differs from ordinary telephone transmission in that it is unidirectional, and one-way amplifiers are employed. Since a studio may either transmit or receive programmes, it is necessary to provide means for changing the direction of transmission over the network. In the past this has been done either by using separate facilities which transmit in opposite directions, or by interchanging the input and the output of the amplifiers by the use of switches manually operated.

To provide quicker reversals, a remotely controlled reversing circuit has been developed which permits the reversal of the circuits to be controlled from the studio originating the programme. Reversals are effected by relays, controlled by direct current transmitted over the two conductors of the programme circuit, and returned through the earth. Any studio may assume control and set up the network so as to transmit the programme from it to the other points on the network. As long as this studio

retains control, no other studio can alter the conditions. The reversing equipment is required at every amplifier point, which may be a simple amplifier station along the line, or a main junction or terminal connecting to a broadcast studio.

Swiss Electrotechnical Industry during War-time

In the February issue of *Swiss Technics*, a journal published by the Swiss Office for the Development of Trade (Zurich and Lausanne), which co-operates with the Swiss Association of Machinery Manufacturers, Zurich, there is an instructive account of a visit made to the Secheron Works at Geneva. These works have always been strictly limited to the construction of heavy electrical machinery and material. A few years ago, when the electrification of the chief Swiss railroads, to which the Secheron Works greatly contributed, drew to a close, new lines of manufacture were taken up. Among these was the building of electric welding apparatus and the manufacture of the necessary electrodes. The Secheron alternating-current arc-welding apparatus has now almost everywhere replaced direct-current revolving units. For the welding of complicated parts 'exotherme' electrodes are almost universally employed; cut-out or stamped parts can be simply welded together by the melting of the electrode into the space left between them, thus forming a solid block as homogeneous as a foundry casting.

Enormous alternators for the hydro-electric power station of Verbois are now being constructed at the works. These machines resemble two-storied towers, 9·2 metres high and each weighing 300 tons. All parts are electrically welded and every welding has been carefully inspected by radiograph. At normal speed the peripheral speed of the polar wheel will be equal to 155 km. per hour; at 300 rev. per min. this speed attains 350 km. per hour. A 3,000-h.p. motor is being built for Norway and twelve transformers of 1,000, 2,000 and 3,200 kva. are being built for Ireland.

Electro-formed Reflectors

The construction recently of 62-in. searchlight reflectors at the Bart Laboratories, New Jersey, shows, according to the *Electrical Review* of April 11, that satisfactory progress is being made in modern electro-forming methods. An electro-formed nickel-surfaced mould is first of all made and a coat of nickel 0·003–0·005 in. thick is applied to the outer passivated nickel face. Then follows a coating of copper, to which a pre-formed bronze ring is applied, and the assembly is given a heavy deposit of copper. These firmly bonded layers are stripped from the mould in the form of a bi-metal reflector with copper on the convex face and nickel on the inner polished face. To prevent the introduction of copper into the rhodium bath, a protective mask is fitted on the copper side. The reflector is now ready to receive its rhodium-plating, and in this instance a 'flash' of rhodium 30 millionths of an inch thick appears satisfactory.

The advantage of this method appears to be in the use of rhodium on a nickel base. It has a high hardness (about 600 Brinell), is tightly adherent to its underlying layer, and also has a high degree of reflectivity and resistance to tarnish. The coatings of rhodium used are exceptionally thin; but as nickel is passive when plated with rhodium, adequate protection is provided. It is stated that full protection is lacking with underlayers of copper and its alloys, the relation of which to rhodium in electro-chemical action is such that disfigurement by corrosion may result.

Japan Institute for the Science of Labour

The annual report of the Director of the Japan Institute for the Science of Labour for 1939, recently received, in reviewing the present activities of the Institute, emphasizes its objectives in assisting the development of the national industrial capacity, including the training of workers, as well as the improvement of working conditions, and the stimulation of leadership. Reference is made to the investigation of industrial hazards as well as of the problems of agricultural workers, including their maintenance. A somewhat naïve claim is made for the uniqueness of the Institute, as well as a reference to its part in the establishment of a 'New Order' in the Orient. The report also includes the director's address on the "Function and Guiding Spirit of the Institute", given at its first staff conference, in which the character of the Institute as a purely scientific research body covering the daily life of the industrial and agricultural worker is emphasized, and also the importance of its contribution to national productivity and culture. Stress is laid upon the team spirit in the research work of the Institute and its service of social and national needs. Details of the various research sections and laboratories of the Institute are given, as well as of projects already under investigation.

Thin Glass for Microscope Cover-Slips

The year 1940 marked the centenary of the manufacture in Great Britain of specially thin glass for microscope cover-slips. Prior to this date, it was customary for microscopists to use thin talc or mica for covering specimens to be examined under the microscope. This manufacture was started by Messrs. Chance Brothers and Co., Ltd., at Smethwick, in 1840 as nearly as is known, and has been carried on continuously by the same firm up to the present day. The War has called for a considerable increase in supplies of such glass, both in Great Britain and abroad. There was no essential change in this type of glass until about 1928, when a research was carried out on the development of microscope cover-slips. It was found that the old type of glass, which was essentially like window glass, would not withstand tropical conditions without becoming clouded. Therefore, new methods of manufacturing a glass which would withstand sterilizing and exposure to tropical atmospheres without any deterioration were introduced. The thickness of cover-slip glass is still classified under the headings: Extra thin (0·075–0·100 mm.), No. 1 (0·100–0·167 mm.), No. 2 (0·167–

0·215 mm.), and No. 3 (0·215–0·300 mm.). These correspond closely with the figures quoted in a catalogue issued by the firm in March 1859, which says No. 1 is 1/250 in. in thickness, No. 2 1/160 in., and No. 3 about 1/100 in.

Vital Statistics in Queensland

OUT of a total of 9,530 deaths in Queensland in 1939, 2,786 were classified as due to diseases of the heart or circulatory system. Cancer and other tumours were responsible for 1,069, and diseases of the respiratory system for 811. Parasitic and infectious diseases claimed a total of 747, the chief of these being pulmonary tuberculosis (290) and influenza (221). Violent or accidental deaths claimed 812 victims. Out of a mean population of 1,013,000, more than 95,000 received treatment at public hospitals during the year.

Earthquakes Registered at Kew

BETWEEN May 18 and June 15, seven large earthquakes were registered by the seismographs at Kew Observatory. These were on May 23 (two), 24 and 30, June 6, 10 and 11. The two shocks on May 23 were from the same epicentre 2,850 km. distant. They commenced with compressional waves at 19h. 57m. 17s. and 22h. 39m. 33s. G.M.T. respectively, and the first attained a maximum ground amplitude at Kew of 24 μ. The shock of May 30 at 21h. 47m. 32s. G.M.T. from 17,000 km. may have had a focal depth of about 400 km. and the shock of June 10 at 20h. 46m. 10s. G.M.T. from 4,900 km. may also have had a deep focus (450 km.). The other shocks were smaller, and all the readings and calculations are tentative.

Earthquake in Baja, California

THE United States Coast and Geodetic Survey, in co-operation with Science Service and the Jesuit Seismological Association, on the basis of reports from fourteen seismograph stations, has found the epicentre of the earthquake of March 15, 1941, at 5h. 46·3m. G.M.T. to be provisionally at latitude 28·1° N., longitude 113·6° W. This is south-west of Calmalli and towards the northern end of the Vizcaino Desert, in an established seismic region.

Wilhelm Preyer (1841–1897)

PROF. WILHELM THIERRY PREYER, a well-known German biochemist and psychologist, was born on July 4, 1841, at Moss Side, Manchester. He studied in Bonn, Heidelberg, Berlin, Vienna and Paris, where he was a pupil of Claude Bernard and Wurtz. In 1869 he was appointed professor of physiology at Jena, where he remained until 1888. He then moved to Berlin, where he served as lecturer until 1893 when he retired, and died at Wiesbaden on July 15, 1897.

Preyer was a prolific writer, first in biochemistry and later in psychology. His biochemical publications were concerned with hæmoglobin and methæmoglobin (1868), blood acids (1868–70), blood crystals (1871), while his psychological works included the five senses of mankind (1870), the causes of sleep (1877), colour and temperature sense (1881), discovery of hypnotism (1881), and the soul of the child, which went through eight editions (1882–1912).

The Night Sky in July

THE moon is full on July 8 at 20·3h. and new on July 24 at 7·7h.U.T. The bright star, Aldebaran (magnitude 1·1), is occulted by the moon on July 20. As seen from Greenwich the predicted time of disappearance is 2h. 47·0m. U.T. at position angle 38° from the north point of the moon's image; the reappearance is at 3h. 34·$_0$m. at position angle 297°. (sunrise is at 4h. 5m.: add 2h. to all times to convert to Midsummer Time). Of the planets visible during this month, Venus is low in the west after sunset and not easily seen. Mars is above the eastern horizon at about 23½h. in mid-July. The gibbous phase of its disk can be seen in a small telescope. The planet is increasing in brightness. Saturn and Jupiter are both morning stars. Saturn is in conjunction with the moon on July 19d. 1h. and Jupiter on July 20d. 9h. After the middle of the month, Mercury may be seen as a morning star, greatest elongation (20° west) occurring on July 24.

Announcements

SIR HENRY DALE has announced in a letter in *The Times* the gift by the American Physiological Society of 5,000 dollars to the Royal Society "for the support of British scientific publications, especially in physiology". This is the third gift recently made by American scientific institutions to aid science in Britain; the Rockefeller Institution made a grant for publications (NATURE, Feb. 22, p. 237) and the American Philosophical Society has given 10,000 dollars "for the aid of science in Britain" (NATURE, April 5, p. 414).

PROF. FRANK HORTON, professor of physics in the University of London, has been re-elected vice-chancellor of the University for the year 1941–42.

DR. R. J. W. Le Fevre, lecturer in chemistry at University College, has been appointed reader in the University in respect of that post.

THE following doctorates have been conferred: *D.Sc.* on Mr. Bruce Chalmers, of University College, and on Mr. S. G. Clarke, of Battersea Polytechnic; *D.Sc.* (*Economics*) on Mr. S. K. Muranjan, of the London School of Economics.

AN Academy of Sciences has been established at Tiflis, Georgia, in connexion with the University.

THE Trustees of the Lady Tata Memorial Fund announce that, on the recommendation of the Scientific Advisory Committee, they have agreed, if circumstances permit, to make the following awards for research in blood diseases, with special reference to leukæmia, in the academic year beginning on October 1: Grants for research expenses to Dr. J. Furth (New York), Dr. P. A. Gorer (London) and Dr. A. H. T. Robb-Smith (Oxford); part-time personal grant and grant for research expenses to Dr. W. Jacobson (Cambridge).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. They cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

Quantum Theory of X-Ray Reflexion

In a memoir which appeared in 1926, Laue[1] showed by purely classical reasoning that the X-rays scattered by elastic solid waves of thermal origin in a crystal have the frequency $\nu \pm \nu^*$, ν being the primary X-ray frequency and ν^* the frequency of the elastic waves. He evaluated I_ν and $I_{\nu \pm \nu^*}$, these being respectively the intensities of the reflexion and the scattering by any assigned set of lattice planes in the crystal. The value of $I_{\nu \pm \nu^*}$ for any specified direction of scattering may be found by assigning the appropriate wave-length and orientation to the elastic waves in Laue's formula. The ratio $I_\nu / I_{\nu \pm \nu^*}$ comes out, as might naturally be expected, to be of the order N, this being the total number of atoms in the irradiated solid. Even for a tiny crystal only 1μ in size, the ratio is thus of the order 10^{11}. In other words, the scattering in any specified direction by the lattice planes has an intensity wholly negligible in comparison with that of the coherent reflexion by the same planes.

In an article published in *Current Science* of April 1940, and in a series of three papers following it in the *Proceedings of the Indian Academy of Sciences* for May 1940, experimental evidence was presented showing that the lattice planes in a crystal are capable of giving a second kind of specular reflexion which differs from the reflexions of the classical type in being of a dynamic character and having an altered frequency, besides obeying different geometric laws. Experimental evidence was also presented showing that these reflexions are due to the excitation of the *optical* vibrations of the crystal lattice, and reasons were given for the view that this new type of reflexion is a quantum-mechanical effect.

Other alternative theories of the phenomenon have appeared which, in our view, are neither in accord with accepted physical principles nor with the experimental facts emerging from our investigations. We may, in particular, refer to a view which has been repeatedly expressed [2,3], namely, that the effects observed are diffuse maxima in the scattering of X-rays by elastic waves of thermal origin. This suggestion is, in our opinion, completely contradicted by the observed intensity of the reflexions and their persistence over a large range of settings of the crystal. As shown by our investigations, the intensity ratio between the unmodified and modified reflexions of monochromatic X-rays varies greatly with the crystal, its setting and with the spacing studied; it is generally of the order 1000 : 1, but certainly nothing like 10^{11}. The actual facts of the case can only be understood on the view that we are dealing with the optical vibrations of the crystal lattice; these produce large dynamic variations of the structure amplitudes and negligible distortions of the lattice, unlike the elastic waves, in respect of which the situation is exactly the opposite.

As is well understood at the present time, classical optics and quantum mechanics are mutually complementary and not contradictory. Classical optics indicates that a crystal in which the interpenetrating lattices vibrate with reference to each other would give intense specular reflexions of X-rays with an altered frequency. When, therefore, such an effect is actually observed, it is a legitimate inference that the changes in the energy level of the crystal associated with such a reflexion are to be regarded as induced by the incident radiation itself; in other words, that the intensity of the reflexions is determined by quantum dynamics and not by the classical mechanics. This view led us to predict[4] that the intensity of the modified reflexions by the (111) planes of diamond would remain unaffected by cooling the crystal down to liquid air temperatures. This prediction has been completely confirmed by our experiments[5]. Neither the high elasticity of diamond nor the existence of a zero-point energy appear to us to be in any way relevant as an explanation of the observed facts[6].

C. V. Raman.
P. Nilakantan.
P. Rama Pisharoty.

Department of Physics,
Indian Institute of Science,
Bangalore.
May 2.

[1] Laue, *Ann. Phys.*, **81**, 877 (1926).
[2] Zachariasen, *Phys. Rev.*, **57**, 597 (1940).
[3] Lonsdale, NATURE, **146**, 806 (1940).
[4] Raman and Nilakantan, *Proc. Ind. Acad. Sci.*, **11**, 396 (1940).
[5] Raman and Nilakantan, NATURE, **147**, 119 (1941).
[6] Jahn and Lonsdale, NATURE, **147**, 88 (1941).

The Lightning and Spark Discharges

It has recently been pointed out[1] that though the charge leaving the cloud in a lightning flash to earth is probably about half as great again as had hitherto been believed, the potential of the thundercloud base is probably only a few per cent of previous estimates[2]. It already appears[1] that the condition for the occurrence of a flash is not that the breakdown potential be attained over the whole intervening space[2,3], but that a concentration of field should occur of sufficient intensity to initiate what may be called a 'self-propagating' discharge in a field which elsewhere may only reach a few hundred volts per cm. The implications of this are so important in the theory of discharges in general that further confirmation is very desirable. The purpose of this note is to suggest a mechanism to account for the 'darts' of the first leader stroke and the low overall voltage, to direct attention to a characteristic of such discharges which has hitherto been overlooked, and to suggest the condition under which spark breakdown occurs.

One characteristic of the first leader stroke which is nearly always observed is its discontinuous or 'dart'-like appearance[4], which in my opinion has not so far been satisfactorily accounted for. The explanation now proposed is that the *'darts' represent the sudden transition of newly formed portions of the*

advancing streamer from glow to arc conditions. As the streamer advances, an increasing current must flow through the tip of the preceding dart to maintain the increasing lateral or corona current from the sides of the streamer. When this current, together with the small current involved in the vertical progression of the tip, builds up to the order of one or a few amperes, sudden transition from glow to arc will occur[5, 6, 7]. The order of magnitude at least of the current attained when the streamer reaches a length of 7–10 metres, and the average length of the darts, can be estimated from the charge neutralized in the atmosphere by the average lightning flash, namely, about 10 coulombs, of which about half is probably neutralized during the first leader stroke[1]. From the duration of the leader stroke, say 10^{-2} sec., and the length of the lightning channel, say 2·5 km., this neutralization requires a lateral current of the order of 4×10^{-3} amp. per cm. length of channel, or 3–4 amp. over the length of a dart. Allowance for the branching of the first stroke would merely reduce this current by a factor of about 3, so that this current is in good agreement with that for which glow - arc transition occurs.

Further support is derived from a consideration of the transition from arc back to glow. This occurs for a current which is about 10 per cent of that required for glow - arc transition[7], so that arc conditions would not be maintained in the last tenth of the dart length, which would therefore be re-illuminated by the succeeding dart, just as has been actually observed by Schonland[4]. Again, Allibone and Meek[8] observed that currents of the same order flowed during the leader stroke of the spark discharge, and it is interesting to observe that, owing to their rapidly varying nature, the currents in the leader strokes in this case were often greater than those of the subsequent return strokes, a conclusion supported by the relative photographic intensities of the two strokes.

Such an arc channel can be regarded simply as an extension of the initiating conductor, and the voltage gradient along it is only of the order of 10 volts per cm. These considerations explain the 'self-propagating' nature of the discharge and the large charge neutralized by the corona, which is thus seen to be an important, though hitherto unrecognized, feature of the discharge.

The condition for the occurrence of a spark in a non-homogeneous field would thus appear to be that *the current in the brush discharge from an electrode should be sufficient to cause glow - arc transition to occur*, after which the leader progresses by the above mechanism.

A more detailed account of this work will be published shortly.

C. E. R. BRUCE.

British Electrical and Allied
Industries Research Association,
15, Savoy Street,
London, W.C.2.
May 29.

[1] Bruce, C. E. R., and Golde, R. H., *J. Inst. Elect. Eng.* (in press).
[2] Wilson, C. T. R., *Phil. Trans. Roy. Soc.*, **221**, 73 (1921).
[3] Meek, J. M., *Phys. Rev.*, **55**, 972 (May 15, 1939).
[4] Schonland, B. F. J., Malan, D. J., and Collens, H., *Proc. Roy. Soc.*, A, **152**, 595 (1935).
[5] Todd, F. C., and Browne, T. E., *Phys. Rev.*, **36**, 732 (Aug. 15, 1930).
[6] Fan, H. Y., *Phys. Rev.*, **55**, 769 (April 15, 1939).
[7] Attwood, S. S., Dow, W. G., and Krausnick, W., *Trans. Amer. Inst. Elect. Eng.*, **50** (3), 854 (Sept., 1931).
[8] Allibone, T. E., and Meek, J. M., *Proc. Roy. Soc.*, A, **166**, 97 (1939).

An Effect of Light in Gases under Electrical Discharge

THE observation reported previously[1], namely, an instantaneous diminution of the discharge current in chlorine on irradiation, has now been extended to other gases subjected to ionization by collision in electric fields due to alternating potentials in Siemens' tubes.

It is observed that the photo-variation of the discharge current varies rapidly in the order: chlorine, bromine, hydrochloric acid gas, iodine. In fact, observation of the effect in iodine is nearly impossible without a sensitive indicator and adequate irradiation. Furthermore, especially in the case of iodine, the photo-effect is easily masked by a dark, in part, 'ageing' effect, that is, a time-variation of the discharge current produced under a constant applied potential; this varies in the order: iodine, bromine, chlorine. Other conditions remaining the same, a rise in the gas pressure and temperature tends to diminish the light-effect; an increase in the applied potential, frequency of the A.C. supply and of the external radiation employed, as also its intensity, increases it.

Preliminary experiments have shown that differences in the magnitude of the light-effect in chlorine using plane polarized and equally intense ordinary light lie within the margin of probable experimental error.

The use of larger discharge tubes, radiation of much greater intensity and of shorter wave-length, and of specially sensitive current indicators has revealed the effect in oxygen, air, nitrogen and hydrogen; its magnitude is, however, very considerably smaller in these gases than in the case of the halogens.

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G. S. DESHMUKH.

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[1] *Current Science*, **9**, 535–537 (1940).

Pigmentary Changes and the Background Response in Amphibia

THE results of recent experiments of mine have shown that our conception of the nature of the background response in Amphibia is inadequate and must be extended. When *Rana temporaria* is kept on an illuminated black background for several weeks, melanin granules are dispersed in the melanophores and the amount of melanin in the skin is increased. Conversely, when the animal is kept on a white background, melanin granules are aggregated in the pigment cells and the amount of melanin in the skin is decreased. In short, additive and subtractive processes are operative. Both effects have been observed by means of photometric determinations of solutions of melanin extracted from the skin, and the latter effect is apparent microscopically in the degeneration of melanophores[1].

Other experiments of mine have tended to show that the amount of melanin in the retinal pigment epithelium of *Rana temporaria* varies under certain conditions. When the eye has received the radiations from a Hanovia lamp, melanin granules may be densely aggregated at the same time in both the basal regions and the processes of the retinal pigment cells. A condition thus arises which is not

pathological and which combines the pigmentary characters of both the dark- and the light-adapted eye. For this and other reasons, the idea of pigment migration in the retina has been criticized and it has been suggested that whether or not actual movement of granules occurs as a result of cytoplasmic streaming such as has been postulated, other processes are probably at work. One possibility is the concomitant bleaching or destruction of pigment and colour intensification or the development of pigment in different parts of the pigment cells[3].

Since my papers went to press, I have discovered in the literature facts which have some bearing on my work and which deserve brief comment. Figge[3] repeated the experiments of Lewis[4] on the development of pallor in the larvæ of amphibians reared in solutions of dyes which are also oxidation-reduction indicators. Pallor seemed to imply the destruction of melanin, but was found to arise in consequence of the inhibition of tyrosinase action by the dye[5]. Tyrosinase is regulated by oxidation-reduction potentials, and in a mixture of melanin with redox indicators, sodium hydrosulphite not only decolorizes the dye but also alters black melanin to a light brown colour. The subsequent addition of potassium ferricyanide to the mixture reverses the change and restores to the pigment its former black colour. Figge concluded that melanin is a natural reversible oxidation-reduction system.[6]

Natural melanin, like the pigment produced by autoxidation of dihydroxyphenylalanine (dopa), is capable of reversible oxidation and reduction, but the reaction is far more sluggish and barely perceptible, perhaps because of the low concentrations used in the tests and of contaminants in the reaction mixture. The pure melanin which occurs in the ink of the squid *Loligo pealii* was found to be almost as reactive as dopa melanin and capable likewise of alternate oxidation and reduction repeatedly with corresponding colour change and without significant final loss of colour[7].

These facts suggest that the pallor which is due to the white background response may involve alteration rather than actual degradation of melanin. If such pallor is due to the inhibition of tyrosinase action, however, the loss of melanin can be explained on the assumption that under conditions of neutral background the pigment is being both produced and excreted or otherwise lost continually, and that under conditions of white background melanogenesis is suspended while the excretion of melanin continues. Some pigment must be lost at all times and under all conditions by moulting of the epidermis, and unpublished observations of mine show that more is lost by this means in dark than in pale animals. From this it seems likely that under conditions of black background melanogenesis is heightened even more considerably than the experimental data in my earlier paper suggest.

If apparent loss of melanin under conditions of white background is due even in part to discharge of the black colour by alteration of melanin, the observations of Figge suggest that the cause is to be sought in oxidation-reduction processes of pigmented tissues. Such a possibility was in fact in my mind when I made the suggestion of bleaching and darkening processes as an alternative to the idea of pigment migration in the retinal pigment epithelium. It now seems likely also in regard to the skin and other tissues in which melanin is to be found.

A further possibility presents itself, namely, the interaction of melanin and/or its precursors (at least two of which are capable of reversible oxidation and reduction) with other systems of similar nature, notably lyochromes but also carotenoids. It seems significant that lactoflavin is accumulated in the pigment epithelium of the perch retina[8], and that in non-scaly fishes like the eel the melanophores of the skin have a high flavin content[9]. If melanin and its precursors are functionally related to such important systems as the flavoproteins and carotenoids, pigmentary changes in the skin and the retina acquire physiological significance and the occurrence of melanophores in the walls of blood capillaries, the membranes of central nervous organs, and the other deep situations in which they seem incongruous is less enigmatical.

BEN DAWES.

King's College, London
(at the University of Bristol). June 5.

[1] Dawes, B., *J. Exp. Biol.*, **18**, 26 (1941) (I should like to express my regret at the misspelling in this paper of the name Vilter).
[2] Dawes, B., *J. Exp. Biol.* (in the press).
[3] Figge, F. H. J., *J. Exp. Zool.*, **73**, 471 (1938).
[4] Lewis, M. R., *J. Exp. Zool.*, **64**, 57 (1932).
[5] Figge, F. H. J., *Proc. Soc. Exp. Biol. and Med.*, **33**, 569 (1938).
[6] Figge, F. H. J., *Proc. Soc. Exp. Biol. and Med.*, **41**, 127 (1939).
[7] Figge, F. H. J., *Proc. Soc. Exp. Biol. and Med.*, **44**, 293 (1940).
[8] Zewi, M., *Finska Läkesällsk. Handb.*, **80**, 923 (1937).
[9] Fontaine, M., and Busnel, R. S., *C.R.*, **206**, 372 (1938).

"Vegetables as Food"

Drs. Booth, Mapson and Moore[1] feel that in a recent article in Nature[2] I exaggerated when I made "an allusion, divorced from its context, to cooked cabbage as having only 17 per cent of the vitamin C of the fresh cabbage". What I wrote was as follows. "A cabbage bought at the market may perhaps be expected to contain 60 per cent of its original vitamin C content, the housewife probably throws away no more than 20 per cent of the remainder in preparing the vegetable for the pot, leaving 40 per cent [more correctly 48 per cent] of the original vitamin. During boiling, however, . . . about 65 per cent is extracted by the cooking water and usually thrown away. Thus 17 per cent of the vitamin C with which the cabbage left the field is all that remains when it reaches the table."

I still believe this statement to be substantially true. When the urban housewife buys her cabbage it may be some days old, and loss of freshness carries with it loss of vitamin C. After she has bought it, part at least may be stored for a further period in her larder or kitchen, where further loss occurs. Miss Olliver, in an address of which my article was in part a review, showed that only 37 per cent of the original vitamin C may remain in shop-purchased cabbage, although, as she also shows, there may in better circumstances be no loss at all. I do not therefore feel that my figure of 60 per cent is unfair. My next figure of 20 per cent loss in preparing the vegetable for the pot is admittedly an estimate, but bearing in mind that the heavy outside leaves which are discarded are richest in vitamin C, I hoped it was not unreasonable. The losses of the remaining vitamin during boiling shown in Miss Olliver's tables which she had kindly made available to me were as follows:

Cabbage:	62,	62,	61,	69*,	66,	53,	66 per cent.
Kale:	67,	46,	77*,	76*,	78*,	71*,	84 per cent.

* Probably normal method of cooking.

I am aware that losses of the order of 40-50 per cent can be achieved, and in agreement with the Cambridge workers I myself have obtained figures as low as 20 per cent. The bulk of the evidence seems to show, however, that, in general, losses of vitamin C are very high.

Dr. Booth and his colleagues will receive the thanks of all workers in nutrition for their figures for carotene in carrots. Anyone who has occasion to use published tables of carotene values knows the bewilderment of choosing from a confusion of figures often differing many fold. But while the position of vegetables as sources of carotene and hence of vitamin A available to the body has not yet been completely elucidated, the standing of green vegetables as a source of vitamin C is beyond dispute. As Miss Olliver and Mr. Adam truly state[3] they "can adequately supply the full daily requirement of the vitamin". This they do, I cannot help believing, only after the bulk of the vitamin supplied by bountiful Nature has been lost. Can we afford to lose so much in present times?

Vitamins Ltd.,
London, W.6. AGNUS PYKE.

[1] NATURE, **147**, 711 (1941).
[2] Pyke, M., NATURE, **147**, 513 (1941).
[3] NATURE, **147**, 711 (1941).

Whilst it is an accepted fact that there may be considerable wastage of vitamin C when vegetables are cooked, any statement which tends to underestimate the antiscorbutic value of cooked vegetables is to be deprecated.

Dr. Pyke's original article tends to give this impression, and it is unfortunate that such an impression should be confirmed by the choice in the above letter of figures separated from their context.

M. OLLIVER.

Science and Society

HITHERTO most apologists for science have done little more than stress the potential value of aspects of technology, such as would provide new foods, weapons and other *things*. Until recently this was the only non-cultural justification of science, but to maintain it now is out of date.

Our society may be likened to a badly run office, the directors of which are ready to call in a tradesman to stop a leak obvious to the senses, but have no idea of using intelligence and skill of another order to put a stop to ineffective methods in the running of the office itself. Let not men of science put themselves in the position of forming only a works and repairs department of the office, with no concern except to press for more and better plumbing, or to suggest that it need not be confined to repairs.

The politician, a victim of his education, is unaware of common scientific concepts such as limiting values and the elementary theory of errors. It appears that his notions of equilibria are represented by arithmetical averages in a static two-phase system, and that he can conceive of no interactions more complex than those of a game of chess—in which one piece is moved at a time. The chances are even that subjective decisions will be wrong; nor is any test of their validity possible.

As a result of work in the field of mathematical statistics, our generation is the first to have the power of applying objective tests to many social problems. To this ability is added the practicability of assessing the validity of the results. Scientific thought applied to such matters as the black-out and evacuation could have avoided their anomalies and lessened the harm done to our national effort. Unfortunately, it was not officially realized that such problems were amenable to objective methods.

The new discipline has been developed primarily in Britain and secondarily in the United States. It is little known on the Continent and is not used at all in Germany or Italy. I suggest that its incorporation into our social methods might well be our answer to the apparent German monopoly of positive ideas.

35 Tennyson Road,
Harpenden, Herts. HUGH NICOL.

Infestation of Manufactured Food by Insects

DR. D. N. ROY'S letter in NATURE of June 14, p. 746, suggests that the special problem to which he refers is something apart from the problems which I described in my report to the Department of Scientific and Industrial Research. In fact, it is the kind of problem to which I directed attention.

Some years ago, considerable time and study was given in my department to the cause of infestation of a manufactured commodity similar to, if not identical with, that referred to by Dr. Roy. The conclusion reached was that as precautions had been taken to ensure bottling of the commodity under sterile conditions the method of sealing was at fault. In the course of the investigation, evidence was obtained that infestation might occur at almost any point in the marketing of the commodity, and that a most likely point or focus of infestation was the Indian go-downs in which, according to reports I received, the beetles Silvanus and Tribolium were abundant.

Imperial College of Science
and Technology,
London, S.W.7. J. W. MUNRO.

"Plankton as a Source of Food"

THERE is one point which I should like to add to Prof. Hardy's article on "Plankton as a Source of Food"[1]. He is concerned chiefly, and rightly so, with marine plankton. Would it not be possible to make use also of the freshwater plankton from our lakes and reservoirs? In this connexion I may refer to a statement by (the late) C. H. H. Harold[2], that a certain reservoir was estimated to contain 10,800 tons (wet weight) of algæ; and even allowing that that estimate is somewhat of an exaggeration, an appreciable quantity must have been present, for he goes on to say that 90 tons were removed daily by filtration. More recently, Gardiner[3] speaks of a reservoir having, at the spring maximum, a crop of *Fragilaria crotonensis* estimated at a *dry* weight of 110 tons. It would seem, therefore, that here, at least, is ample material for investigation.

Department of Biochemistry,
University Museum,
Oxford. June 13. E. WALKER.

[1] NATURE, **147**, 695 (1941).
[2] Proc. Second Inter. Congress for Microbiology (London, 1936), p. 212.
[3] *Ann. App. Biol.*, Proc. Assoc. of Applied Biologists, **26**, 165 (1939).

RESEARCH ITEMS

Evolution of Sex Chromosomes

M. J. D. WHITE (*J. Gen.*, **42**, 143–172 and 173–190; 1941) has examined the sex-chromosome mechanisms in praying mantids and in the crickets and grasshoppers. The majority of the Mantoidea have an *XO–XX* sex chromosome mechanism; the *X*-chromosome is mediocentric. In the sub-family Mantiniæ *sensu strictu* a $X_1X_2Y_1 : X_1X_1X_2X_2$ mechanism has been developed. The author shows that this probably arose from the *XO* type by a mutual translocation between the *X* and an autosome. The sizes of the component chromosomes may differ as the result of succeeding translocations. Meiosis appears to be of an anomalous type, and it would seem impossible to determine by cytological methods whether crossing-over occurs, since chiasmata are not seen. It is shown that translocation simultaneously involving both *X* and autosomes in the Tettigondæ occurs rarely if at all. The *X* is therefore in evolutionary isolation. Therefore differences in sizes and shape of the *X*-chromosomes of neighbouring genera have arisen from internal rearrangements. These rearrangements may be beneficial in readjusting genic balance, upon which sex determination depends.

Origin of Cherries

T. RAPTOPOULOS (*J. Gen.*, **42**, 91–113; 1941) has examined the cytological behaviour of Duke, sour and sweet cherries and several hybrids. He shows that the Duke cherries and the sour cherries are autotetraploids, but of different origins. The Duke cherry probably is a tetraploid derivative of *Prunus avium*, whereas the sour cherries probably arose from a species cognate to *Prunus avium* which differed in a number of genetic characters. The quantitative data on which the above conclusions are based are that the Duke cherries have a high chiasma frequency (1·59) while the sour cherries have a lower frequency (1·34). When crossed together, the sour cherries are able to produce as many quadrivalent configurations as in the Dukes themselves. Hence selection has taken place in the sour cherry for low chiasma frequency. There is an inverse ratio between fertility and number of quadrivalents in nine species and varieties of tetraploid cherries.

Ultra-Violet Absorption by *Drosophila melanogaster*

SINCE ultra-violet radiation gives rise to lethal gene mutations in Drosophila, it is important to know how much radiation penetrates the body cells before reaching the sperms. As a first approximation, E. Durand, A. Hollaender and M. B. Houlahon (*J. Hered.*, **32**, 51–56; 1941) have observed the absorption of radiation by the abdominal wall between 2140 A. and 4400 A. under an ultra-violet microscope. It was found that the abdominal wall is unexpectedly transparent. Below 3000 A. there is a rapid increase in absorption; this ranges from about 20 per cent at 4400 A. to about 94 per cent at 2500 A. It is necessary, therefore, to know the amount of absorption in the overlying tissue in order to know the dose which induces gene mutation in the testis.

Wing Development in Drosophila

MANY genes affect the characters of *Drosophila melanogaster*, and, as shown by Waddington, these affect the wing at different stages of development. A. D. Lees (*J. Gen.*, **42**, 115–142; 1941) has wounded the developing wing of pupæ 0–3½ hours old, 4–6 hours old and 6–21 hours old. Wounding the wings of the youngest pupæ gave rise to tilt, fused, vesiculation and scalloping effects. Wounding of the 4-hour-old pupæ gives characteristic rounded wings due to an inhibition of cell multiplication and to the dumpy effect. Injury of the older pupæ leads to holes in the epithelium, to production of extra veins as in Delta, and alteration of the position of the posterior cross vein. These experiments shed considerable light on the means by which one gene may affect a final character expression by disturbance of the normal development at a particular stage.

Behaviour of Nitrogen and Hydrogen on Osmium

HABER in his classical researches on the synthesis of ammonia found that osmium was an excellent catalyst. The catalysts for this important synthesis have commanded much attention. Recently H. S. Taylor and Joris have investigated the exchange of nitrogen isotopes on a promoted iron catalyst, and they have now extended their studies to an unpromoted, metallic osmium catalyst (*J. Chem. Physics*, **9**, 287; 1941), prepared by the decomposition-reduction of ammonium osmium chloride in a stream of hydrogen at 300° C. Activated adsorption of hydrogen on osmium occurs between 80° and 573° K., but at low temperatures a certain amount of van der Waals' adsorption is also evident. With nitrogen, throughout the same temperature range, van der Waals' adsorption decreases as the temperature is increased. The isobar at 1 atmosphere shows a minimum at 350° and then increases, due to activated adsorption, to a maximum at 428°. The nitrogen adsorption is less than 10 per cent of the hydrogen adsorption at one atmosphere between 273° and 573°. At 473° the isotopic exchange of nitrogen, $^{28}N_2 + {}^{30}N_2 = 2\,{}^{29}N_2$, is just measurable, but at 573° it is very rapid and has an activation energy of 21·8 kgm.cal. The reaction is inhibited by hydrogen and becomes unmeasurable when the hydrogen content exceeds 50 per cent. Ammonia decomposes six times as fast as the rate of the exchange reaction and yields a 1 : 3 nitrogen-hydrogen mixture. The mechanism of the exchange appears to be controlled by the migration of atomically bound nitrogen on a surface on which active centres are few. The area per gram of osmium has been calculated as 30·8 square metres, but only 4 per cent of this area is covered by nitrogen at the temperature of maximum activated adsorption (428°).

Optically Active Dyes

THE present view of the mechanism of the dyeing of textile fibres is that it occurs in three stages: (1) diffusion of the dye into the submicroscopic voids of the fibre, (2) adsorption of the dye, (3) irreversible fixation of the dye. The nature of the union between the

dye molecule and fibre molecule is not established, but it is generally supposed to be a physical adsorptive phenomenon occurring through hydrogen bonds and secondary valencies in the dyeing of vegetable fibres, and chemical phenomena such as salt formation in the dyeing of animal fibres. But the distinction between these two types of combination is not sharp, and the process might be the result of both. Some slight evidence of optically selective adsorption of one form of a dye containing an asymmetric carbon atom, claimed by Morgan and Skinner in 1925, has not been substantiated, so that the partial resolution of a dye in the racemic form in associating with the optically active structure of protein and cellulose fibres, which would favour a chemical combination, is not proved. W. R. Brode and R. E. Brooks (*J. Amer. Chem. Soc.*, **63**, 923; 1941) have now synthesized a dye in which the whole molecule, and not merely a carbon atom well removed from the origin of colour, is asymmetric, and the chromophore and auxochrome groups are situated as nearly as possible to the seat of optical activity. It was prepared by tetrazotization of the active and racemic forms of 2, 2′-diamino-1, 1′-dinaphythyl and coupling with phenyl-*J*-acid. Dyeing tests with these active and racemic dyes failed to show any selective absorption by wool or rayon fibres, and support a physical, rather than a chemical, combination between fibre and dyestuff.

Vapour Density of Iodine

AT ordinary temperatures, iodine consists of diatomic molecules. At 600° dissociation is less than 1 per cent, but at 1200° it is 50 per cent. The equilibrium $I_2 \rightleftarrows 2I$ has been previously investigated several times, but there is a lack of concordance among the data. A re-examination has been made by G. K. Rollefson and Perlman (*J. Chem. Physics*, **9**, 362; 1941) in order to obtain reliable data and to test experimentally if existing difficulties arise from the presence of triatomic molecules, which, on theoretical grounds, are considered sufficiently stable to exist in the vapour state (*J. Amer. Chem. Soc.*, **54**, 170; 1932). The pressure – volume products of iodine vapour were measured between 723° and 1274° K. In this region iodine vapour contains no trace of triatomic molecules, but is an equilibrium mixture of I_2 and I. From equilibrium constants and known energy levels of I_2 and I, the heat of dissociation of iodine is $35{,}514 \pm 50$ gm.cal., in close agreement with the value obtained directly from spectroscopic data.

Design of Joint Boxes for Super-Tension Cables

C. E. ROSE has published a useful practical paper on the design of a joint for splicing together consecutive cable-lengths or for connecting up cables to station switchgear (*Eng. Supp., Siemens Mag.*, No. 292, 1941). One of the main causes of trouble results from the expansion caused by the temperature effects of the load. The expansion of insulating compound used in joints is of the order of about 3 per cent over the usual working temperature range. Cable oil expands to an even greater extent when the conductors are carrying heavy loads, exerting pressure on the lead sheaths and sealing ends, and so tends to penetrate the joint boxes. When solid compounds are used for filling the joints and end boxes, up to 11 kilovolt working voltage, a high melting-point solid-setting compound of bituminous nature is usually employed. This tends to act as a barrier to the flow of cable oil. Provision has to be made in the end boxes for the expansion of this compound and also for the seeping of the cable oil, which may soften the solid compound in places where they come into contact. For voltages greater than 11 kilovolts, a compound of a semi-fluid nature with a similar constitution to that of the cable impregnating oil is used for filling joint sleeves and end boxes. Hence all boxes used for these compounds must be perfectly oil-tight. Where steep gradients occur in the cable route, it may be advisable to stop the interchange of compound between the cable and the joint so as to isolate each length of cable on a slope. This will limit the pressure set up at the lower end of each cable length, and prevent undue draining of the cable oil. These joints are known as barrier joints and virtually comprise a double-end box, each cable terminating on either side of the barrier plate.

Limits of Uniform Galactic Absorption

THE results of investigations on the question of general galactic absorption have been rather discordant. This is partly due to the recognized irregular distribution of the absorbing matter, partly to the uncertainty about the distances of the stars, and partly to the non-homogeneous working material which includes early stars, late stars, Cepheids, open clusters, etc. George Alter has now shown that in a uniform and continuous absorbing galactic layer, it is possible to determine the absorbing conditions by the observed relation between colour index and absolute magnitude (*Mon. Not. Roy. Astro. Soc.*, **101**, 2; 1941). An investigation is made on the limits for the photovisual, photographic and selective absorption coefficients, and the two assumptions of this investigation are based on experience. If an additional theoretical assumption is made, the selective law, derived by Stebbins, Huffer and Whitford, these limits are restricted further. Some suggestions are made for the determination of the actual coefficients. One of these is that the absorption conditions in the 'galactic windows' might be carefully investigated, the influence of absorbing clouds being thus avoided so far as possible.

Stellar Lithium

RECENT theories of energy generation in the cooler stars (see, for example, NATURE, **144**, 575; 1939) postulate the interaction of protons and the nuclei of light elements such as lithium in stellar interiors. Until now the only extra-terrestrial evidence for the existence of lithium atoms has been the faint occurrence in the solar spectrum of the resonance doublet of neutral lithium at 6708 A., the lithium analogue of the sodium *D* lines. Now, however, Dr. A. McKellar reports (*Observatory*, **64**, 4; 1941) that this doublet occurs strongly in the spectrum of the *N*-type giant variable star *WZ* Cassiopeiæ, being second in intensity only to the *D* lines themselves. A puzzling feature of the discovery is that this star is alone among the ten or more *R*- and *N*-type stars examined by McKellar in showing the lithium lines; yet in other respects, such as absolute magnitude and radius, it does not appear abnormal. Astrophysicists are always loth to attribute abnormal strength of a spectral line to abnormal abundance of the emitting element, but the facts here do seem to suggest that lithium is unusually abundant in the atmosphere of this particular star.

THE ROCKEFELLER FOUNDATION

IN his review of the work of the Rockefeller Foundation in 1940, the president, Dr. Raymond B. Fosdick, refers to the limitation of the Foundation's work through the extension of the War. Projects in Norway, Belgium, Holland, Denmark, France and Rumania could no longer be assisted, but in spite of this interference, 23 per cent of the Rockefeller Foundation appropriations of 9,854,497 dollars during the year were spent abroad in forty-four countries in Europe, Asia, Africa and the Americas in six major fields—public health, natural sciences, social sciences, medical sciences, humanities and rural reconstruction in China. Early in July 1940, a Health Commission to Europe was organized, and Dr. Willow A. Sawyer, director of the International Health Division, made two extended trips to Europe, visiting France, England, Spain and Portugal. A bacteriologist-epidemiologist has been sent to England at the request of the Ministry of Health to study the influenza problem, and plans are under way to send one or more experts in nutrition and a specialist in typhus fever to Spain, and a bacteriologist-epidemiologist to France. Restrictions of communications between Europe and America have severely limited the development of this programme, but Dr. Fosdick refers to work in the Foundation's laboratories under Dr. F. L. Horsfall on the development of a satisfactory anti-influenza vaccine. It is hoped that by the winter of 1941–42 an experimental vaccine will be available which can be applied to at least three different types of the influenza disease.

The report gives further details of the progress of the campaign against the *Anopheles gambiæ* mosquito in Brazil, which has now restricted the activities of this fly to the low Jaguaribe valley, and it appears possible to contemplate its eradication from Brazil. Investigations on yellow fever in Colombia suggest that it is primarily a disease of jungle animals, transmission from man to man by the *Ædes ægypti* mosquito being a secondary cycle depending on population conditions and mosquito breeding created by man himself. Transmission of jungle yellow fever appears to be by jungle mosquitoes from animal to animal, and there is no animal reservoir of virus in the usual sense. Vaccination of the population in contact with the infected forest area is the most important measure of control. The Foundation supplied 250,000 doses of its yellow fever vaccine to the Sudan at the request of the British Government to deal with a sharp outbreak of the fever in the Nubian mountains.

A new school of public health is being developed at the University of Michigan with a grant of 500,000 dollars from the Foundation and a similar sum from the W. K. Kellogg Foundation. Most of the appropriations in medical sciences in 1940 relate to teaching and research in psychiatry, neurology and psychology or preventive medicine. Reference is also made to the new giant cyclotron under construction at Berkeley, California, and its significance as an expression of man's hunger for knowledge and unassuageable search for truth. Here, as in his references to science and the moral order, to the challenge to the social sciences, to refugee scientific workers and the conditions in European universities, Dr. Fosdick once more reveals his appreciation of the way in which freedom and scholarship, science and learning, are bound up with the success of the cause of democracy.

SEASONAL RHYTHM OF A FLY

By Dr. Ll. Lloyd,
University of Leeds

PROLONGED and uniform trapping of the flies emerging from the bacteria beds of sewage works at Leeds has demonstrated a type of seasonal rhythm that is probably common in rapidly breeding insects. *Spaniotoma minima* Mg. (Chironomidæ) prevails throughout the year, and during eight years of collecting has appeared in almost every week. It is at a minimum about April, increases to a maximum in August or September and then declines rather slowly. On the basis of the monthly totals the numerical change is steady and the curve of incidence is moulded partly by the progress-temperature law and partly by the pressure of competing species[1]. If the weekly catches from the traps are considered, it is seen that whether the general seasonal abundance is low or high there are peak periods of emergence, shallow and obtuse in winter, sharp and abrupt in summer, abrupt and with a tendency to be flat-topped in autumn. There is evidently a periodicity in these peaks and the interval is less than that required for a complete life-cycle. An analysis of the figures shows that successions of generations are running, always two and sometimes three.

One such succession, *A*, has been traced through seventeen generations from November 13–17, 1937, to October 14–21, 1940, when it reaches a flat-topped peak which splits. Another succession, *B*, has been traced through nine generations from October 23, 1937, to the summer of 1939, when it loses itself in *A*. A third, *C*, has been traced from December 17, 1938, when it has its origin in *B*, through eight generations to November 6, 1940. *A*, *B* and *C* run distinctly and parallel through almost one year. A portion of the record where *A* and *C* are running is shown in the accompanying table.

The generations have been traced by means of the daily average bed temperature and the thermal constants, the theoretical thresholds and required accumulations of day-degrees (*F*.) for the four phases of the cycle being as follows: maturation of the

ALTERNATION OF A SUCCESSION OF TWO GENERATIONS *A* AND *C* OF A FLY (*Spaniotoma minima*) AND A SIMILAR SERIES *a* AND *b* OBTAINED BY THEORY FROM AN ORIGINALLY UNIFORM POPULATION. TRAPPING NUMBERS ARE IN HUNDREDS.

1940	Trapping	Theory	1940	Trapping	Theory
March 6	0·6	0	July 3	5·3	5
13	0·7	1	10	5·3	8 *b*
20	0·6	0	17	12·5	3
27	1·3 *C*	5 *a*	24	48·0 *C*	5
April 3	1·3 *C*	6 *a*	31	15·0	15 *a*
10	0·2	1	Aug. 7	38·0	8
17	0·02	2	14	58·4 *A*	7
24	0·09	4	21	59·3 *A*	2
May 1	0·4	3	28	24·1	8 *b*
8	2·3	7	Sept. 4	74·3 *C*	6
15	4·7 *A*	6	11	63·5 *C*	9 *a*
22	0·3	1	18	35·0	5
29	2·8	8 *b*	25	35·4	5
June 5	15·2 *C*	3	Oct. 2	72·2 *A*	3
12	12·2 *C*	14 *a*	9	51·1	6
19	4·9	8	16	72·2 *A*	0
26	6·3 *A*	8	23	56·1	2

female, 32/113·5° ; incubation of the egg, 39·5/68·5° ; growth of the larva, 38·5/689·5° ; pupation, 42/66·5°[2]. The longest cycle observed is 159 days, the theory demanding 146 days ; the shortest is 38 days, theory demanding 32 days. Tracing from peak to peak, the average error in 31 calculations is about 7 per cent, 26 being longer than theory demands while 5 are shorter. Of the former 18 are 1–7 days beyond expectation, and these are substantially accurate since the collections of flies cover the emergence of one week. The behaviour of the insect thus covers expectation very well, and by means of a theoretical case it is possible to show the mechanism that produces the successions.

A uniform population of one unit a day has been imagined from August 7 to September 21, 1937, and it is supposed that their environment has the atmospheric shade temperature of the locality in order to get a sharper contrast and a quicker result than the equable bed temperatures would afford. Offspring from August 7 are due on September 22, so a complete generation has been covered. At first of course the units tend to scatter and regather as spring comes on and in doing so they tend to cluster until by July 1938 a group of six units has clustered for emergence on one day. By July 1939 a second group of six units has formed separated from the first by an interval of 14 days. Three other groups of four units each have also formed, the rest remaining scattered or in twos. By 1940 the population, assessed weekly, has assumed a form strikingly like that of the fly in Nature. Part of the record is shown in the table with the generation intervals marked *a* . . . *a* and *b* . . . *b*. It seems likely that if the calculation were carried through a sufficient number of years the original forty-six units would aggregate into two or three isolated groups. Such an abrupt result could not obtain in Nature partly because a family spreads itself over several days in emergence and partly because of the reversal process.

Moderately abrupt temperature changes extending over a few days near the beginning or near the end of the cycle are responsible for the phenomenon. The spring rises especially tend to cluster the offspring whose parents were widely separated in time. Once a distinctive peak is formed it persists until it happens to be involved in such a change. Sudden temperature falls in autumn especially tend to split the flat-topped peaks mentioned above. In the table, for example, the flies of August 14 just avoid a temperature fall which envelops the second half of the peak on August 21. The result is that a saddle-backed peak develops on October 2–9–16. The split persists in the present year.

It seems imperative that a rapidly breeding insect the speed of development of which is governed solely by the progress-temperature law must behave in this way. *Psychoda alternata*, which also breeds in bacteria beds certainly does so, and its case is being examined in detail. Many insects have their seasonal incidence regulated by the 'diapause', a coma-like state instituted at some suitable point in the life-cycle by ancestral experience of the weather of the average year and calculated to terminate at a time when conditions should be favourable. Sometimes the diapause persists until a second or third favourable season should be due. Thus the likelihood of extermination through an unfavourable season is reduced. The commoner sewage flies show no such phase, but the mechanism here demonstrated and wholely dependent on physico-chemical regulation would seem to serve the same end. *S. minima* requires fairly mild calm weather for the mating dance. A single flight might be unable to achieve mating through encountering a cold stormy period. Repetition of the flight with an interval makes disaster through these means much less likely.

[1] Lloyd, Ll., Graham, J. F., and Reynoldson, T.B., *Ann. App. Biol.* **27**, 122 (1940).
[2] Lloyd, Ll., *J. Proc. Inst. Sewage Purification*, Pt. 1 (1937).

ELIMINATION REACTIONS IN ORGANIC CHEMISTRY

MECHANISM

IN classical organic chemistry, two empirical rules, each of limited application, summarize the regularities which have been observed to govern the formation of olefins from alkyl compounds. Hofmann's rule (an extended form of the rule originally given by Hofmann), applying to primary alkyl groups in ammonium or sulphonium hydroxides, refers to the preferential production of the least alkylated of the possible alkyl ethylenes. Saytzeff's rule, relating to secondary and tertiary alkyl groups in alkyl halides, expresses the predominating formation of the most alkylated of the possible alkyl ethylenes. Having regard to the close analogy of the elimination reactions of 'onium salts and halides, the contrary tendencies of these two rules is striking. The need for an explanation was strongly emphasized when in 1927 Hofmann's rule was rationalized as a manifestation of the inductive effect[1], that is, of a very general type of molecular polarization, which must from its nature oppose the operation of Saytzeff's rule. We have since been much concerned with the problem of reconciling and rationalizing the two rules, but the work has not been published, because, until comparatively recently, the solution was not established. An outline is now given as it may still be some time before detailed publication is possible.

We refer first to methods. The data hitherto available for summarization in the two rules are mainly 'orientational' ; that is, they relate to the

proportions in which alternative products are formed; such proportions represent at best only the ratios of the rates of simultaneous decompositions. Thus the Hofmann rule refers to the formation of olefins from alternative primary alkyl groups in the 'onium structure, while the Saytzeff rule relates to the alternative isomeric olefins derived from the solitary branched-chain alkyl group of a secondary or tertiary halide. By examining the kinetics of the reactions, we have provided, besides these rate ratios, the individual rate constants, which permit more extensive and much more significant comparison. Thus we are able to include primary alkyl halides, for which orientational data are impossible.

The most important point, however, relates to mechanism. Primary alkyl 'onium salts and halides yield olefins mainly by the bimolecular mechanism *E*2 (attack of a base on an alkyl proton), but the corresponding secondary or tertiary alkyl compounds react partly or wholly by the unimolecular mechanism *E*1 (prior formation of a carbonium ion), and in many cases either mechanism may predominate depending on the conditions. Kinetic control is therefore essential to ensure that only reactions of identical mechanism are compared; and that they are compared on the most appropriate lines. We compare the specific rates for mechanism *E*2, and the ratios in which the carbonium ion is partitioned between elimination and substitution for mechanism *E*1. The comparative simplicity of the results is essentially dependent on the use of the kinetic method.

The data reveal two distinct and characteristic sets of constitutional influences, of which the Hofmann and Saytzeff rules respectively are partial statements: we retain these names for the extended groups of phenomena. Their fields of control are as follows. 'Onium salt reactions proceeding by mechanism *E*2 display 'Hofmann influences'; those going by mechanism *E*1 show 'Saytzeff influences'. Halide reactions by both mechanisms *E*2 and *E*1 are governed by Saytzeff influences. Within the investigated range, these statements remain true no matter whether the alkyl groups are primary, secondary, or tertiary, provided that they are saturated. The introduction of suitably placed unsaturation increases the field of application of Saytzeff influences.

When Hofmann influences are present, the successive variation R = H, Me, Et, etc. in $R.\overset{\beta}{C}H_2.\overset{\alpha}{C}H_2.X$ leads to an initial sharp decrease, followed by successively smaller decreases, in the bimolecular rate of elimination. These rate relations, as well as those applying to more complicated alkyl groups, are consistent with the belief that the responsible internal mechanism is the inductive effect: electron displacement in the bond RC_β decreases the induced positive charge on C_β, thereby inhibiting the loss of the β-proton.

When Saytzeff influences are in control, the variation R = H, Me, Et, in $R.CH_2.CH_2.X$ leads to an initial sharp increase followed, not by any further increase, but by a decrease of smaller magnitude than the original increase in the bimolecular rate, or unimolecular partition ratio for elimination. These relations, and those observed with more complex groups, are consistent with the theory that the responsible mechanism involves resonance due to the quasi-conjugation[2] of the HC_γ-electrons with the electrons transferred in elimination from the dissolving HC_β-bond to the forming $C_\beta C_\alpha$-double-bond: the energy of quasi-conjugation facilitates this electron transference and thus promotes the proton loss. The greater the number of HC_γ-bonds, the larger will be this effect; and, of course, a much more powerful effect of the same kind arises when, in place of quasi-conjugation, full conjugation is produced by the provision of γ-unsaturation as in the β-phenylethyl group.

Thus for elimination reactions we envisage a situation very similar to that already elucidated for aromatic substitution: independent electrostatic and resonance effects co-exist; and being separately energized they may even work in opposition. When they do, the question of their relative importance assumes special interest.

We expect the importance of quasi-conjugation to increase with the electron defect developed at C_α in the transition state of olefin formation; for the effect depends on the possibility of the electromeric displacement, $H\overset{\frown}{-}C\overset{\frown}{-}C=C_\alpha$ in the transition state.

We find that in fact Saytzeff influences are subsidiary in the *E*2 reactions of 'onium salts, dominating in the *E*2 reactions of halides, and more strongly dominating in the *E*1 reactions of either 'onium salts or halides; in short, these influences increase when the precursor of the olefin successively contains the groups $C_\alpha-\overset{+}{X}$, C_α—Hal, $\overset{+}{C}_\alpha$. The electron defect at C_α is clearly greatest in the last example; and we may reasonably expect it to be greater in the second than in the first, because the stretching of the C—Hal bond is assisted by solvation due to the charges created by a partial electron transfer from C to Hal, while a corresponding energetic factor is lacking in the activation of the bond $C-\overset{+}{X}$.

We may add that other reactions leading to olefins, for example, those of alcohols and ethers, fall consistently within the theoretical scheme outlined.

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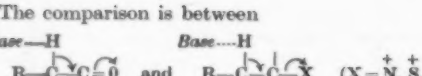
[1] Hanhart and Ingold, *J. Chem. Soc.*, 997 (1927).
[2] Cf. Hughes, Ingold, Masterman and MacNulty, *J. Chem. Soc.*, 908 (1940). This mechanism is identical with that which Mulliken, Rieke and Brown have recently termed 'hyperconjugation' and for the first time treated quantitatively: *J. Amer. Chem. Soc.*, **63**, 41 (1941).

TAUTOMERISM AND ELIMINATION

About twenty years ago the outlook on theoretical problems connected with tautomerism was considerably enlarged by the proposal to regard tautomeric changes, for certain purposes, as internal analogues of additive reactions[1]; thus the study of ring-chain tautomerism developed as a direct consequence of this point of view. It is curious that the complementary and equally valid idea of regarding tautomeric change as an internal form of elimination seems never to have been explored. Consideration shows that it leads to many striking analogies and correlations. This note is confined to a single illustration chosen because it happens to be simply explicable in terms of the preceding communication.

The comparison is between



the former diagram representing the rate-determining step of a base-catalysed enolization, the latter an ordinary elimination by mechanism *E*2. The difference is that the combination CO does not break up completely while CX does. The question to be considered is whether the effect of alkyl groups R on the rate of enolization of a ketone (now regarded as an elimination reaction) will be of the 'Hofmann type' or the 'Saytzeff type'. Relatively to CX, the stretching of CO in the transition state must be small, and accordingly the electron defect on the carbon atom and the dependent quasi-conjugation, developed in the course of reaction, may be assumed to be comparatively unimportant. It is therefore not surprising that the effect of alkyl groups on rate is found to be of the Hofmann type. This may be illustrated by Evans and Gordon's results[2] for the rate of bromination (kinetically equivalent to enolization) of phenyl alkyl ketones, CHRR′.CO.Ph in the presence of acetate ions as basic catalyst :

R,R′	H,H	Me,H	Et,H	Pr$^{\beta}$,H.	Me,Me
$10^3k_{45°}$	52·0	7·99	6·24	3·05	1·55

Examples of 'Hofmann influences' are also to be found in the effect of alkyl substitution on rate of interconversion in the case of 'three-carbon' prototropy.

A contrast to these effects on reaction rate is afforded by evidence that the effects of alkyl substituents on prototropic equilibria are essentially dependent on the same internal mechanism as underlies what have here been called Saytzeff influences on rate (preceding note). The ground states alone are important for equilibria, with the result that, in the tautomerism of olefinic acids, for example, the introduction of a γ-alkyl group shifts the equilibrium in favour of the βγ-form. Consistently a methyl group is more effective in this respect than higher alkyl groups. This effect may be illustrated by the results of Kon and Linstead[3] for the base-catalysed equilibria of the anions of a series of acrylic acids, RR′C=CH.CO_2H :

RR′	Me_2	Et_2	Pr^{α}_2	*iso*-Bu_2
γ-substituent	.H	.CH_3	.CH_2CH_3	.CH(CH_3)$_2$
αβ-form (%)	100	5	33	49

The importance of quasi-conjugation for equilibria may also be illustrated with reference to anionotropic change. The predominating formation of crotyl and cinnamyl halides in the equilibration of the butenyl and phenylpropenyl halides are familiar examples.

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[1] Ingold, E. H., *Chem. and Ind.*, **42**, 1245 (1923); *J. Chem. Soc.*, **123**, 1717 (1923).
[2] *J. Chem. Soc.*, 1434 (1938).
[3] Cf. Kon and May, *J. Chem. Soc.*, 1549 (1927); Ingold, *Ann. Rep. Chem. Soc.*, **24**, 112 (1927).

FORTHCOMING EVENTS

Friday, July 4

GEOLOGISTS' ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. A. J. Bull: Opening Paper of a Discussion on "Pleistocene Chronology".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

LECTURER IN MATHEMATICS—The Secretary, Technical College, Sunderland (July 5).

LECTURER IN THE DEPARTMENT OF MINING—The Registrar, University, Leeds (July 7).

LECTURER FOR THE CIVIL AND MECHANICAL ENGINEERING DEPARTMENT—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1 (July 7).

REPORTS AND OTHER PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Empire Cotton Growing Corporation. Annual Report for the Season 1939–1940. Pp. ii+34. (London: Empire Cotton Growing Corporation.) [285

Institute of Physics. Twenty-first Annual Report of the Board, 1940. Pp. 16. (Reading: Institute of Physics, c/o The University.) [66

Eating for Victory: Suggestions for War-time Economy in Foodstuffs. A Sequel to "Grass for All". By J. R. B. Branson. Pp. 29. (Bordon, Hants.: Branson's Publications.) 4*d*. [66

Annual Report of the Zoological Society of Scotland for the Year ending 31st March 1941. Pp. 28. (Edinburgh: Zoological Society of Scotland.) [66

Carnegie United Kingdom Trust. Twenty-seventh Annual Report, 1940. Pp. vi+46+2 plates. (Dunfermline: Carnegie United Kingdom Trust.) [66

Institution of Gas Engineers. Communication No. 240: The Gas Industry, 1941 and After: a Symposium. Pp. 60. (London: Institution of Gas Engineers.) [66

Other Countries

Herbertia. Vol. 7, Dedicated to Latin America. Edited by Hamilton P. Traub. Pp. 242. (Orlando, Fla.: American Amaryllis Society.) 3.25 dollars. [285

United States Department of Agriculture: Weather Bureau. Monthly Weather Review, Supplement No. 46: Observations of Nocturnal Radiation at Fairbanks, Alaska, and Fargo, N. Dak. Pp. ii+22. (Washington, D.C.: Government Printing Office.) 10 cents. [285

Field Museum of Natural History. Botanical Series, Vol. 9, No. 6: Studies of the Vegetation of Missouri. 2: Phanerogamic Flora of the Fresh-Water Springs in the Ozarks of Missouri. By Julian A. Steyermark. (Publication 491.) Pp. 477–618+24 plates. 1.25 dollars. Zoological Series, Vol. 22, No. 7: New and Little Known Neotropical Histeridae (Coleoptera). By Rupert L. Wenzel and Henry S. Dybas. (Publication 492.) Pp. 431–472+plates 13–16. 40 cents. Zoological Series, Vol. 24, No. 19: Birds from the Yucatan Peninsula. By Melvin A. Taylor, Jr. (Publication 493.) Pp. 195–226. 20 cents. (Chicago: Field Museum of Natural History.) [285

Geological Survey of British Guiana. Bulletin No. 15: Report on the Geology and Mineral Deposits of the Upper Waini River, North West District. By Dr. D. A. Bryn Davies. Pp. iii+22. (Georgetown: Geological Survey.) 24 cents. [46

Indian Forest Records (New Series). Botany, Vol. 1, No. 7: Contributions to our Knowledge of the Morphology, Cytology and Biology of Indian Coniferous Rusts. Part 1: *Cronartium himalayense* Bagchee and *Peridermium orientale* Cooke on *Pinus longifolia* Roxb. By K. Bagchee. Pp. iii+247–266. (Delhi: Manager of Publications.) 1.6 rupees; 2*s*. [66

Recent Developments in the Science of Plant and Animal Nutrition and their Significance to National Nutrition and Health. Presidential Address to the Section of Chemistry and Biology, 10th Annual Meeting of the National Academy of Sciences, February 1941, by Rao Bahadur B. Viswa Nath. Pp. 31+iii. (New Delhi: The Author, Imperial Agricultural Research Institute.) [66

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